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8 A Summary of Current Program and
Preliminary Report of Progress

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POULTRY RESEARCH

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United States Department of Agriculture
and Cooperating Agencies

C & R-PREP.

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

December 1, 1963

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research and Service
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton and Tobacco Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Soil and Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite

Agricultural Marketing Service (AMS)

- 4 - Market Quality
- 4 - Transportation and Facilities

Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

Other Services

- 1 - Soil Conservation Service (SCS)
- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)

Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering
Crops
Entomology

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- | | |
|--|--|
| 1 - Cross Commodity Research of
Agricultural Engineering, Crops,
& Entomology Research Divisions | 8 - Cotton and Cottonseed
8 - Tobacco |
| 3 - Rural Dwellings | 9 - Grain and Forage Crops |
| 6 - Forestry (Other than Forest
Service) | 10 - Citrus and Subtropical Fruit |
| 7 - Beef Cattle | 10 - Deciduous Fruit & Tree Nut |
| 7 - Dairy | 10 - Potato |
| 7 - Poultry | 10 - Vegetable |
| 7 - Sheep and Wool | 10 - Florist, Nursery & Shade Tree |
| 7 - Swine | 11 - Oilseed and Peanut |
| 7 - Cross-Specie & Miscellaneous
Animal Research | 11 - Sugar |

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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INTRODUCTION

This report on poultry research covers work directly related to the production, processing, distribution, and consumption of poultry and poultry products. The information has been assembled from the organizational unit reports of the several divisions. This report does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only poultry problems but also to the problems of other commodities. Progress on cross-commodity work is found in the reports of the several divisions such as Soil and Water Conservation, Human Nutrition, Transportation and Facilities, Farm Production Economics, Foreign Development and Trade Analysis, and Cross-Species and Miscellaneous Animal Research.

This report is devoted to the 18 "problem areas" shown in the table of contents. For each area there is a statement of (1) the Problem, (2) the USDA Program, (3) A summary of Progress during the past year on USDA and cooperative work, and (4) A list of Publications resulting from USDA and cooperative work.

Research on poultry and poultry products can be divided into three major categories, i.e., that supported by (1) Federal funds appropriated to the research agencies of the United States Department of Agriculture, (2) Federal and State funds appropriated to the 53 State Agricultural Experiment Stations, and (3) private funds allotted, largely by poultry industries, to research carried on in private laboratories or to support of State Station or USDA work. For all three categories it is estimated that about 1,100 scientists are engaged in research dealing specifically with the production, processing, distribution, and consumption of poultry and poultry products. Support of their work involves an annual expenditure of between 25 and 30 million dollars. This amounts to about 0.8 percent of the cash farm receipts from poultry and eggs and about 0.5 percent of the retail cost of poultry and eggs. Of the 1,100 scientists engaged in poultry research, approximately 13% are employed by the Department of Agriculture, 27% by the State Experiment Stations, and 60% by other universities, foundations, and private industry.

Research by USDA

Farm research pertaining to poultry is conducted in the Agricultural Research Service divisions of Agricultural Engineering, Animal Disease and Parasite, Animal Husbandry, and Entomology. The work comprises investigations of breeding, physiology, nutrition, viability, diseases, insects, housing and management, involving 80 professional man-years of scientific effort.

Nutrition, consumer, and industrial use research pertaining to poultry is conducted in the Agricultural Research Service divisions of Human Nutrition, Consumer and Food Economics, and Western Utilization. The work comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions; and with the processing phase involving slaughtering the birds and processing the meat and eggs. Also, it is concerned with improved equipment and processes. The work in these divisions involves 39 professional man-years of scientific effort.

Marketing and economic research pertaining to poultry is carried on within four Services: Agricultural Marketing Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing, and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, AMS; Transportation and Facilities, AMS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; Standards and Research, SRS. The scientific effort involved by these divisions amounts to 20 professional man-years.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects poultry research is carried on by 51 State Experiment Stations. The types of work to which the largest amount of effort is devoted include nutrition, physiology and management, breeding, diseases and economics of marketing. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Privately supported poultry research emphasizes the solution of scientific production, processing, and marketing problems. Much of it utilizes the results of more basic work done by State Station and Department scientists.

Major areas of emphasis include poultry nutrition and breeding. This is peculiar to the poultry industry. For other animal species much of the nutrition and breeding work is done with public research. Private research in processing is devoted largely to control methods, standardization of products, and product quality and formulation. Research in marketing and economics by industry is in connection with new product development and in merchandising and promoting farm products. Industry participates heavily in consumer acceptance research but largely with respect to a firm's own brand name.

The contributions of poultry producers and industry to the work of the State Stations and the Department have been an important factor in the success of their research programs. Producers offer flocks and facilities for testing products and practices used in production. Likewise, processors and retailers offer facilities and products for use by public research agencies. Many problems in the economics of marketing cannot be transferred to a laboratory, experimental plot, or other simulated situation. The results of economic research conducted cooperatively is of great value to industry, especially in cases where public research can provide comparison and analysis. Even large firms that have a research staff do not have access to the plants and records of competitors.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Ventilation of livestock buildings. Research in cooperation with State Experiment Stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy, and swine buildings. They appear in design handbooks including the 1962 Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of livestock production that has occurred during the past decade.

Fatty acid deficiency in the laying hen. After two years' effort the first true fatty acid deficiency, with easily recognized symptoms, was produced in laying hens after a long depletion period. The symptoms are extreme susceptibility to respiratory infection and an alteration in fat metabolism to produce a rare and as yet undesignated fatty acid. A progressive degree of deficiency resulted in

small egg size, prolongation of hatching time, severe decrease in egg production, and eventually zero hatchability. It has been shown that, of the several fatty acids formerly thought to be essential, only linoleic acid is essential in the laying hen.

Ethylene Dibromide Fumigant Affects Egg Laying. Although ethylene dibromide has been used for many years as a fumigant for food and feed grains, it was only in the last few years that poultry farmers suspected that it affected egg laying. Research under an AMS contract at the University of Georgia has now shown that about 5 p.p.m. of ethylene dibromide in the feed of hens definitely reduces the size of eggs. The rate of egg production was not affected by 50 p.p.m., but 80 p.p.m. caused a significant drop, and 160 p.p.m. stopped production completely within 7 weeks. As a result of these studies, the grain and poultry industries are being cautioned against the use of ethylene dibromide for treating grain destined for poultry feed.

Post-Mortem Metabolic Changes Related to Poultry Tenderness. Department scientists have shown that the rate at which glycogen breaks down in muscle to yield lactic acid influences the tenderness of poultry. Undue stimulation of the muscle at or soon after slaughter (for example, by excessive scalding, beating in pickers, and electric shock) accelerates glycolysis and the onset of rigor. This leads to abnormal toughness. However, if glycolysis is avoided by use of chemical inhibitors or by pre-slaughter injection with adrenalin which exhausts the normal glycogen reserve, birds are tender without the 6- to 12-hour aging period that is usually required. Thus, the occurrence of glycolysis was found to be a cause of toughness. Aging permits poultry to become tender again, the degree of tenderness depending on how fast glycolysis has occurred. This better understanding of post-mortem chemistry of poultry muscle should lead to more efficient methods for producing optimum tenderness in poultry products.

Mechanized Chicken Parts Sizing and Packing Line Developed. Under the RMA Contract, initial work has been completed on the development of a prototype line, for use by processing plants, in sizing chicken parts and packing them in containers of exact predetermined weights. The line essentially consists of two components: (1) A parts classifier (by weight) with bins for receiving classified parts and (2) a packing station equipped with a scale and "memory system." To pack seven drumsticks in a one-pound package, six "sized" parts are placed in an empty package on the packing-station scale. A light then flashes over the bin from which the seventh drumstick must

come to give the exact one-pound weight. Estimates are that this equipment can save up to \$100,000 annually in a large plant by reducing the amount of meat given away in overweight packages. The reduction in packing and weighing labor also should be sizeable.

Strengthening Cooperatives through Consolidation. Poultry cooperatives are finding it necessary to merge or unify operations to improve services and keep pace with changes in poultry production and marketing. FCS has studied the feasibility of cooperative mergers in California, Utah, and Pennsylvania. Steps are underway by the cooperatives in these States to put merger recommendations into effect. Completion of the consolidation plans will eliminate duplicate services, reduce costs, increase returns to members, and result in stronger bargaining power for poultry producers. Other recent studies have included dairy, artificial breeding, grain and farm supply cooperatives.

Baking Temperature to Make Dried Egg Products Safe from Salmonella.

Baked foods containing dried egg can be safe from Salmonella organisms if temperature throughout the product reaches a minimum of 160° F. The point of slowest heating may be slightly above the center for viscous and high protein foods. Division scientists established these findings from measurements of heat penetration during the baking of 24 food products made with dried eggs. Instructions have been developed for safe use of dried egg in the Federal school lunch program and in food distribution programs for institutions, summer camps, and welfare families.

POULTRY - BREEDING
Animal Husbandry Research Division, ARS

Problem. Poultry breeders have made greater use of current genetic knowledge than any other group of livestock breeders. So widely have new principles been adopted in the industry that many breeders question whether further progress is being made in improving certain traits. They believe that the useful genetic variation already may have been exhausted. Information is needed as to the relative rates of progress which will result from various breeding systems for improving such economic traits as egg and meat production traits. Furthermore, information is needed as to whether or not different systems of breeding are required at different stages of the breeding program. Knowledge is required on the heritabilities, genetic correlations and gene-environment interactions, and the consequences of selection on these parameters, in order to design the most efficient breeding systems. Information on the physiological basis for the action of certain genes would lead to a better understanding of controlling heredity for optimum performance. Also, economics of production should be improved through basic knowledge on the genetic aspects of feed utilization efficiency and of various stresses during selection.

USDA PROGRAM

This is a continuing long-term program involving basic and applied studies of the inheritance of egg production and broiler characteristics. Scientists with majors in genetics or biochemistry and minors in physiology or statistics are involved. Much of the research is conducted within the framework of four regional projects. In addition to financial aid to several of the State contributing projects and major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel located at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort. Research at Beltsville, Maryland, involves the selection of lines under stress of nutritional deficiency and for differences in feed utilization efficiency, including a study of genetic, chemical and physiological differences between these lines. Selection for response in egg production to "18-hour" days is conducted in cooperation with AERD. Research in the North Central region is on egg production traits and is done at the Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 12 cooperating State experiment stations. In the Southern region the major emphasis is on broiler traits and the work is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 14 cooperating State experiment stations. The work in the northeastern region involves the improvement of chickens through genetic and physiological studies and is conducted under cooperative projects at 11 cooperating State experiment stations. Cooperative work on turkeys is carried on with six Western States.

A Research and Marketing Act contract with Purdue University Agricultural Experiment Station provides for a study of the genetic statistics of inbred lines of poultry and their combination in single crosses, four-way crosses, and top-crosses. This two-year study utilizes data accumulated from the North Central Regional Poultry Breeding Project and will be completed in 1964.

A grant to the Animal and Poultry Breeding Department, Ministry of Agriculture, Dekki, Giza, Egyptian Region, U. A. R., provides for a study of improving and evaluating Fayoumi and Dandarawi fowls. Its duration is for four years, 1963-1968, and involves PL-480 funds with a \$131,110 equivalent in Egyptian pounds. (F4-AH-1)

During the past 12 months one line project was terminated and two new ones were initiated. In addition, the P. L. 480 project mentioned above was initiated during this reporting period.

A total of 7.4 professional Federal man-years is devoted to this program annually. Of this number 3.6 man-years are devoted to genetics and interrelations of performance traits, 3.4 to selection and systems of breeding and 0.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits.

1. Genetics aspects of nutritional deficiencies. Selection for fast and slow growth on both a methionine deficient and on a normal diet indicates that lines differing in growth rate can be developed under each environment. Positive and negative genetic change has been made under each environment when compared with the randombred controls. The deficient diet restricted growth so that at 3 weeks of age chicks weighed only approximately one-half that of chicks on a normal diet. The chicks from these four selected lines and the randombred controls are being used for basic biochemical studies. (AH el-48)

2. Genetic aspects of feed utilization. Preliminary studies were conducted with inbred lines of Rhode Island Red and White Leghorn chickens to evaluate feed utilization efficiency. Analysis of data resulting from the individual feeding of laying hens indicates that some lines fairly consistently required less feed than expected, based on body weight, change in body weight, and egg mass produced. Similarly, some lines fairly consistently required more feed than expected, using the same traits and calculations. (AH el-49)

3. Selection for egg production under sub-circadian periodicities. A study of avian reproduction under 18-hour "short days" was initiated to investigate the response, and measure the genetic progress in egg production that can be obtained by a selection program under such a regime.

Differences in production traits between the 18-hour and control populations, although small, were significant. Body weights were higher for the control birds at all observation periods, while hen-housed egg production was superior for the 18-hour population. Average age at first egg was found to be 174 days for the 18-hour birds as opposed to 170 days for the controls. Differences were significant at the five percent level for 20-week body weight, at the ten percent level for hen-housed egg production and at $P < .001$ level for age at first egg, 8 week body weight, and 320 day body weight. Analysis of egg shell data indicated high genetic correlations between percent shell, shell thickness and specific gravity. A regression analysis indicated that a third degree polynomial curve provides the best fit to the relationship between specific gravity and shell thickness. (AH el-47)

4. Gene-environment interactions. Gene-environment interaction studies with both egg and meat production stocks were conducted in connection with the Southern Regional Poultry Breeding Project. Data indicated that the performance of egg production stocks is influenced by interactions between genotype and the environment. Two trials were conducted, each with ten egg production type stocks reared and maintained at each of ten State experiment station locations. Hatching eggs from nine commercial sources and from a randombred control population were hatched at one location and a uniform sample of chicks from each stock was shipped to each test location. Data were obtained for body weight at 8, 18 and 58 weeks of age, sexual maturity (age at first egg), 10-month egg production, egg weight, egg quality and mortality. Highly significant differences (1% level) among sources of stock and test locations were noted for body weight, egg production and sexual maturity. Highly significant differences (1% level) were observed also between the two trials for 8- and 58-week body weights and sexual maturity. For sexual maturity the interactions of source of stock x trial and source of stock x test location were highly significant (1% level). For 18- and 58-week body weights and egg production the source of stock x test location interactions were found to be significant (5% level). All second order interactions between body weight, sexual maturity and egg production were non-significant. (AH el-44)

Ten stocks at the Texas Station were housed in 12-inch laying cages. The pullets were housed with either one or two birds per cage. Results from the study indicate highly significant differences in 18-week body weights between stocks but with no difference due to number per cage or stock x cage interaction. This same result was observed at 58 weeks. Placing two birds per cage significantly reduced age at sexual maturity and the stock x cage interaction was highly significant, accounting for 13.71% of the total variance in sexual maturity. Significant stock x cage and stock x period interactions were observed for egg production. These data indicate that certain stocks lay fewer eggs when two birds are placed in one cage. The number of birds per cage did not influence livability or feed consumption per pullet. (AH el-44)

5. Genetic variation in economic traits. Body conformation measurements on broiler type birds were evaluated at the Arkansas Station. Four workers took two repeated measurements of shank length, keel length, body depth, and breast angle on each bird in two groups of 50 White Wyandotte broilers at 10 weeks of age. One group was from the High-Low line and the other groups from the Low line of the Arkansas Station Wyandottes. The birds were subsequently dressed and eviscerated, and the same workers took two measurements of breast angle and keel length on the dressed carcasses. Repeatability estimates for the various traits and workers were computed. Based on these repeatability estimates the relative accuracy with which the traits were measured ranked in the following descending order for the live birds: shank length, keel length, body depth, and breast angle. More accuracy can be obtained in measuring keel length and breast angle on the dressed carcass than on the live bird. (AH el-44)

Selection at eight weeks of age for high and low body weights by Virginia workers indicated that the lines are continuing to diverge after four generations of selection. Selection for body weight at 8 weeks of age resulted in concomitant changes in body weight at other ages. There were also associated positive responses in semen volume, egg weight and Haugh units to selection for 8-week weight, whereas the relationship was negative with age at sexual maturity and percentage egg production. Correlated responses of unselected traits to selection for breast angle at 8 weeks were less dramatic. There was positive and significant association between the selected trait, breast angle, and each of the correlated traits, body weight and egg weight. Differences between the lines were not significant for semen volume, sexual maturity, egg production or Haugh units. (AH el-44)

Following the fifth generation of selection for single traits, lines for high egg production, large body weight, small body weight, high egg weight and low egg weight lines have been evaluated at Iowa. The large body weight line produced eggs larger in weight but slightly fewer in number than the small body weight line. The high egg weight line also laid somewhat fewer eggs and had larger body weight than the low egg weight line. Leghorns selected for two traits, large body weight and low egg weight, laid at the same rate as those in the line selected for small body weight and high egg weight. However, progress in the two selected traits in each line was positive, indicating that large body weight and small egg size are not seriously antagonistic and can be attained in the same individual. (AH el-43)

Investigations concerning altitude stress revealed that slightly better hatchability was obtained from the higher elevation line (9,100 ft. vs. 7,200 ft.) of Broad Breasted Bronze turkeys when eggs from both lines were set at either the 9,100 ft. or 7,200 ft. elevation locations. Hatchability decreased when the pre-incubation storage period was extended from a 1-7 day holding period to 8-14 and 15-21 days. (AH el-46)

Contrary to results of previous years, the higher elevation line of Broad Breasted White turkeys (7,200 ft. vs. 4,300 ft.) had somewhat lower

hatchability when eggs from both lines were set at either the 7,200 ft. or 4,300 ft. locations. (AH el-46)

6. Genetic variation in chemical or physiological traits. Birds in the line selected at the Maryland Station for high serum cholesterol level had a higher adult serum cholesterol level, slightly lower body weight and higher albumen quality than those in the line selected for a low serum cholesterol level. Differences in production have been small and inconsistent for the two lines. Studies with radioactive (C^{14}) cholesterol suggest that the differences between the two lines are due to a greater excretion of cholesterol by the low line. (AH el-45)

Selection studies for high and low blood pressure indicate that in the fifth generation differences between the two lines were greater than in any previous generation. Mortality in both lines was low with no significant difference in male progeny but an appreciably lower mortality in the hypertension (high line) females. (AH el-45)

A study of the genetic and physiological significance of the red cell antigens in chicks at the Texas Station indicated that survival rate is increased in birds having the B^7 allele as a part of their genotype. The advantage in adult livability was more pronounced in the heterozygous females than among the males from the same inbred line. The effect of blood group genotype upon skin graft survival was studied by the Texas workers in their inbred line number 22. The results of the study indicate that no successful grafts could be made where the donor and recipient had incompatible B blood group genotypes. The D and E systems apparently are more compatible and some successful grafts were obtained. Selection was started to develop lines with high and low homograph survival. (AH el-44)

B. Selection and Systems of Breeding

1. Evaluation of genetic changes produced by various breeding systems. Forty-four samples consisting of various breeding systems under study in the North Central region, their controls and certain crosses between them were compared at the Regional Poultry Breeding Laboratory, Lafayette, Indiana. Twelve of the fifteen selection systems were superior to the Regional Cornell control stock in final percent hen-day egg production. One generation of selection on the Purdue Pool population was ineffective in increasing egg production; however, progeny of the Regional Cornell X Purdue Pool and reciprocal cross were significantly improved over the Purdue Pool parent. (AH el-43)

Breeding systems were evaluated at five Stations in addition to the North Central Regional Poultry Breeding Laboratory. At each location the same foundation stock and controls were used. At each Station single-trait selection for hen-day percent egg production from first egg to about 300 days of age was used. Other traits were recorded but not used for selection.

Selection pressure was maintained at approximately 25 percent for both male and female progeny. Results to date are reported below.

At Purdue, closed flock and reciprocal recurrent selection in Cornell and Purdue Pool populations were compared. In addition, crossbreds of the two control populations were used for closed flock selection. Data indicate that differences exist between the original strains used and the crosses between them. Furthermore, the significant differences noted between the lines are still a reflection of differences between original lines, and after one generation of selection the selected lines are not significantly different from the controls.

At the Kansas Station, family index and reciprocal recurrent selection were the breeding systems studied. Results indicate that after the first generation of selection, seven of nine selected groups had a higher percent hen-day egg production to 500 days of age than the respective controls. Comparisons of hen-day egg production to 260 days of age and 500 days of age for two generations of selection indicate family selection to have resulted in an increase in egg production, the exception being in the within cross family selection group. Recurrent selection lines in this group indicate a lowering of percent egg production and no consistency on a within year control comparison. Other observed but unselected traits showed little or no change from the controls.

The Missouri Station has completed three generations of selection for higher rates of production by both the recurrent selection method and the family selection method. There was no apparent difference in livability which could be related to type of breeding. Data indicate that selection for egg numbers is progressing much faster with the R.I.R. line than with the W.R. line.

At the South Dakota Station various methods of inbreeding are being studied. Twelve inbred lines from the Regional Cornell stock reached inbreeding coefficients of approximately 50% in 1961. Six lines were from selected stock; six were randomly developed. There appeared to be little difference in the performance of pullets from matings of either selected or random inbred males mated to non-inbreds. Traits observed were maturity, hen-day production, egg size and adult body weight. Very little broodiness but relatively high mortality was observed in both groups.

Four generations of sire family selection on the Regional Cornell stock at the North Central Regional Poultry Breeding Laboratory have produced a significant difference in egg production between the restricted inbreeding and inbreeding phases of the system. Dam family selection for three generations on the same base population shows steady improvement in egg production while two generations of individual selection produced no change. (AH el-43)

2. Randombred control populations. Six randombred populations are maintained for use as genetic and environmental controls and as a gene pool for use in initiating new research. Four stocks are maintained at Lafayette, Indiana, primarily for egg production research and two at Athens, Georgia, for meat production research. Hatching eggs are supplied to research workers at experiment stations, to random sample tests and to commercial poultry breeders. (AH el-43, AH el-44)

In a study of the stability of randombred populations, observations on ten morphological traits were recorded at the North Central Regional Poultry Breeding Laboratory over a six year period. This study indicates no significant gene frequency shift in the population studied and maintained in the manner used at the Laboratory. Furthermore, at the Minnesota Station the Regional Cornell Leghorns were maintained at two flock sizes, one consisting of 50 males and 250 females and the other of 15 males and 125 females. Results indicate no differences in hatchability, eight-week body weight or chick mortality through the fifth generation. (AH el-43)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Genetics and Interrelations of Performance Traits

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- Bailey, Bernie B., Fanguy, R. C., and Quisenberry, J. H. 1961. A comparison of effects of continuous and discontinuous x-irradiation upon the mortality of different age chicks. Poultry Sci. 40:1375. (AH el-44)
- Bailey, Bernie B. 1962. The relation of blood group genotypes to the effectiveness of bone marrow transplants in lethally x-irradiated chicks. Ph.D. dissertation, A. and M. College of Texas. (AH el-44)
- Brown, R. V. 1962. Sex differences in hemagglutination response. Immunogenetics Newsletter. 2:8, 115-116. (AH el-43)
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- Brown, R. V. and Nordskog, A. W. 1962. Correlated responses in blood group gene frequencies with selection for body weight and egg weight in the fowl. Records of the Genetics Soc. of Am. 31:76. Abstract. (AH el-43)
- Champion, L. R., Zindel, H. C. and Esmay, M. L. 1962. Poultry science research at the Upper Peninsula Experiment Station, Chatham, Michigan. IV. Population density as related to laying house performance in four experimental laying houses. Mich. Agr. Expt. Sta. Quart. Bul. 45(8):67-83. (AH el-43)
- Cook, R. E., Hess, C. W., Carmon, J. L. and Dembnicki, E. F. 1962. Importance of genotype-environment interactions at various ages in broiler type chickens. Poultry Sci. 41:1637. Abstract. (AH el-44)
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POULTRY - PHYSIOLOGY
Animal Husbandry Research Division, ARS

Problem: Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the body of knowledge upon which ultimately must depend the resolution of many long standing issues of practical import, e. g., the "problems" of fertility, hatchability, growth and egg production. A continuing flow of basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In some important areas, research to date has accomplished little beyond outlining the magnitude of the task at hand. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect any "useful" knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research for the bank of knowledge that can be applied toward useful ends. On the more immediately practical side, increased knowledge of poultry housing, related equipment and other management factors is necessary to provide optimal ranges of operational efficiency.

USDA PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona, the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Farm Electrification Branch, AERD, Columbia University, the National Institutes of Health, and Pennsylvania State University. Federal research in this area calls for 5.7 professional man-years, distributed to subareas as follows: Physiology of reproduction, 4.0; environmental physiology, 1.4; and program leadership, 0.3.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Neuroendocrinology. Work was continued with the hen on the effects of electrical stimulation of the hypothalamus on ovulation. As was noted in the preceding report, stimulation of two hypothalamic regions, the anterior median eminence and ventromedial preoptic area - results in the delay of ovulation of the first follicle of the hen's sequence, apparently by the temporary suppression of the release of ovulation-inducing hormone (OIH). Recent studies have shown that although delays in ovulation

following stimulation of either site are of the same magnitude, the mediation of the effect in the two sites is not the same. In the preoptic region, ovulation is delayed by stimulation with stainless steel or platinum electrodes, or by the mere insertion of electrodes without the use of current. Conversely, the median eminence region responds only to stimulation with stainless steel electrodes, a form of stimulation known to have a prolonged irritative action, due to the electrolytic discharge of metallic ions from the electrode tips. The physiological basis for the differing response in the two areas remains to be elucidated.

In examining the effects of electrical stimulation in the preoptic region on ovulation, it was discovered that brain stimulation in the hen causes premature oviposition of the terminal egg of a recurrent sequence. Further investigation revealed that the degree of premature lay was independent of the time of effective stimulation, and that nearly all premature eggs were laid between the hours of 10 A.M. and noon on the day of normal lay. It was also found that premature lay depended only on operative interference with the brain, and that this effect could not be blocked by deep anesthesia administered at the time of operation. Significantly, the premature oviposition in some hens occurred independently of any effect on ovulation of the mature ovarian follicle.

Because of the current lack of knowledge of mechanisms controlling oviposition in birds, an interpretation of the above results is impossible at this time. The findings are of immediate interest to the reproductive physiologist for at least two reasons: (1) The premature oviposition is not caused by a reflex nervous activation of the uterine musculature, but must be mediated by some complex hormonal mechanism; (2) the remarkable constancy in the time of premature lay strongly suggests that the period of premature lay is governed by diurnal periodicity in some undetermined physiological state of the hen. These facts provide a basis for a new approach to the study of neuroendocrine mechanisms controlling oviposition. (AH e3-15)

A colony of Japanese quail (*Coturnix coturnix japonica*) has been established at Beltsville for the purpose of making comparative studies on the control of ovarian function in birds. A continuous population of 288 adult hens, maintained in individual laying cages in a light-proof room, are being used to study the pattern of ovulation and oviposition. Other workers have established that the quail, like the chicken, lays in recurrent sequences throughout the year. Initial investigations at Beltsville were aimed at determining whether or not successive ovipositions and ovulations in a sequence occur in an association constant enough to permit estimates of the time of ovulation from past records of oviposition.

Ovulation in the quail was found to occur within some 15 to 120 minutes after the time of the preceding oviposition within a sequence. The interval from ovulation to the entrance of the egg into the uterus was found to be about 5-6 hours. The arrival of the egg into the uterus can be readily

detected by digital palpation of this organ through the ventral wall of the abdomen. Early detection of the uterine egg provides a convenient means of distinguishing between a normal ovulation, and an ovulation significantly advanced or delayed by experimental manipulations. Having established the existence of these relationships, it will now be possible to work out the sequence of crucial events in the ovulatory cycle, including the times of follicular maturation and OIH release. (AH e3-15)

2. Parthenogenetic reproduction. In parthenogenetic tests conducted in 1963 an attempt was made to get additional information on the nature and origin of cells that give rise to parthenogenetic embryos.

One point of interest was the characteristic delay exhibited by parthenogenetic cells before they start to develop once the unfertilized eggs have been placed in the incubator. To get more precise information on the degree of variability existing among parthenogenetically developing eggs the following tests were conducted: Thirteen different groups of unfertilized turkey eggs were incubated. Eggs comprising each group were candled after 24 hours, thereafter for the first seven days of incubation. At each candling, eggs in which development could be detected were identified. Eggs not exhibiting development at 24 hours of incubation were recandled at 48 hours and daily thereafter through the seventh day of incubation. All eggs were broken and classified on the 10th day of incubation. Data collected on unfertilized eggs were compared with similar data obtained by candling fertilized turkey eggs. Results of these tests show that less than 8 percent of the parthenogenetically developing embryos could be detected by candling at 24 hours of incubation. Thirty-one percent could be detected after 48 hours and 69 percent after 72 hours. This is in contrast to fertilized eggs in which 96.5% of all embryos could be detected after 24 hours of incubation. This characteristic lag in the onset of development on the part of parthenogenetically developing embryos, plus the fact that most parthenogenetic poult hatch on the 29th or 30th day of incubation, shows that rate of development, once the parthenogenetic cells have become organized, is as rapid as normal cells. The 2-3 day lag in time required for the initiation of development gives some added support for the belief that parthenogenetic embryos arise from isolated cells derived from the multicellular germinal disc. The lag probably represents the time required for isolated cells to multiply and organize into embryos after the eggs are placed in the incubator.

If parthenogenetic embryos are arising from isolated cells, as is postulated, it is conceivable that some treatment could be administered to eggs during critical stages in embryo formation which would be reflected in the level of parthenogenetic development. Such an approach was attempted. Various groups of incubating eggs were subjected to marked fluctuations in temperature on critical days of incubation. Eggs were first immersed for 20 minutes in water at 116-120°F. They were then quickly removed and immersed for 20 minutes in water maintained at 46°F. Groups of unfertilized eggs received this treatment after having been incubated 1, 2, 3, and

4 days. Other groups of eggs serving as controls were not dipped. The rapid temperature change apparently caused no material change in the overall level of parthenogenetic development. Thirty-seven to 48 percent of all eggs dipped, upon return to the incubator, underwent parthenogenetic development. In four groups of controls, development varied from 34 percent to 42 percent. It should be noted, however, that following dipping a higher percentage of embryos were encountered in each of five lots of eggs. More than 15 percent of the unfertilized eggs dipped on the third and fourth day of incubation contained well-formed embryos. Slightly less than eight percent of the undipped eggs serving as controls contained embryos.

In a second series of dipping experiments two antibiotics, penicillium and streptomycin, were added to the cold water bath (500,000 units of penicillium and one gram of streptomycin in 5000 ml. of water). Contraction of the egg contents when eggs were transferred from hot to cold water caused a limited amount of the two antibiotics to be drawn within the egg. Six groups of eggs were involved in these tests, three of which were dipped in cold water containing the two antibiotics and three in cold water without antibiotics. One group of treated eggs, along with its corresponding control, was dipped on the first day of incubation, others on the second and third days of incubation. Four additional groups of eggs were retained in the incubator to serve as untreated controls. In each of the three tests in which antibiotics were employed, a lower incidence of parthenogenetic embryos was encountered: 5.2%, 5.7%, and 8.8% as compared to 10.5%, 10.6%, and 15.6%, respectively, for dipped controls. Corresponding values for the four untreated controls were: 6.3%, 7.1%, 10.0%, and 7.8%, respectively. It would appear, therefore, that the presence of either of the two antibiotics in the cold water tended to reduce the percentage incidence of embryos.

The ability of virgin chicken or turkey hens to produce eggs which will develop parthenogenetically is largely dependent on their genetic constitution. The sire as well as the dam transmit factors to their offspring which are associated with the expression or non-expression of parthenogenetic development. This fact came to light when six cross-bred females whose eggs showed a marked tendency toward parthenogenesis (32.8%) were mated first to Dark Cornish males and subsequently to White Leghorn males. The Dark Cornish males came from a strain of birds showing a pronounced tendency toward parthenogenesis while the White Leghorn males were from a line showing no parthenogenesis.

Thirty-nine backcross virgin females, sired by Dark Cornish males, laid a total of 1201 eggs, of which 134 or 11.2% upon being incubated underwent a limited degree of parthenogenetic development. Thirteen backcross virgin females of the same dams, but sired by White Leghorns, produced 473 eggs, of which only one (0.2%) underwent parthenogenetic development. Thus, the incidence of parthenogenesis in eggs of the progeny of the same hens was 55 times greater when the Dark Cornish rather than White Leghorns served as sires.

A study of the chromosomes of interfamilial hybrids of Dark Cornish chickens and Beltsville Small White turkeys has contributed good evidence that they are true diploid hybrids. Fourteen to fifteen macrochromosomes, with a numerical range of from 6 to 20, were found in the majority of hybrid cells. This number is intermediate between the macrochromosome numbers of 18 for turkeys and 12 for chickens. The hybrid macrochromosomes exhibited no variations in number or behavior which differed from those of normal chickens and turkeys. The lack of identifying characteristics on the chromosomes rendered it impossible to distinguish the parental genomes in the hybrid cells. (AH e3-19)

3. Homograft tolerance. In continuation of a cooperative project with Drs. William V. Healey and Paul S. Russell of Columbia University, College of Physicians and Surgeons, a series of second set wattle skin homografts were transplanted from parthenogenetic Beltsville Small White turkey sires to their surviving progeny by unrelated turkey females. These progeny had received first set skin homografts at least 14 weeks previously. Those progeny which had rejected first set grafts also rejected second set grafts while the one progeny which had accepted the first set graft also accepted the second set graft. Subsequently, a second experiment was performed in which two of the parthenogens in the above experiment donated grafts to two more male and two more female progeny each by unrelated females. Seven of these progeny rejected first and second set grafts in typical first and second set homograft reactions. The eighth recipient has permanently accepted both first and second set grafts. The second set grafts in the second experiment, transplanted only 14 days after rejection of the first set, were promptly rejected as ischaemic, mummified grafts. To our knowledge this is the first report in birds of a second set rejection analogous to the second set "white graft" reaction in mammals, and it is taken as good evidence for a high degree of active transplantation immunity having been acquired by the progeny in response to the first set grafts. All of these results are in complete agreement with the preliminary results and conclusions of the first experiment set forth in last year's report, i.e., that histocompatibility antigens can be present in parthenogenetic sires which are not present in their progeny and therefore parthenogens apparently can be heterozygous at the genetic loci which are assumed to control expression of histocompatibility antigens. (AH e3-20)

B. Environmental Physiology

1. Controlled photoperiods in turkeys. Light restriction by short days and by low intensity during the late growing period was shown to be markedly successful in preconditioning out-of-season turkey females for subsequent reproduction (1962 report). Since both of these methods require blackout facilities, a preliminary experiment was conducted to test the effectiveness of a light preconditioning method that did not require blackout. The method consisted of brooding the turkeys of both sexes for 9 weeks under 24-hour continuous light, then gradually shortening the daily photoperiod of the females to that provided by nature at

the time the birds were 28 weeks of age, which amounted to 14 hours 35 minutes between sunrise and sunset on May 25, 1962. At 29 weeks a stimulatory photoperiod of 17 hours was applied abruptly and was gradually increased to reach 24 hours by September 14; this was continued to the end of the experiment on November 13. A control group of females and males were brooded to 9 weeks under 24 hours of light, then reared to 29 weeks of age under natural light conditions, which involved increasing light days during the growing period prior to production. Differences in reproductive results indicated that the gradual shortening of the daily photoperiod during the growing period caused sexual maturity to be delayed 28 days and egg production for the period ending November 13 to be 17 eggs less than that of the controls, 78 eggs versus 95 eggs. Fertility and hatchability of fertile eggs, however, were higher in the treated birds and resulted in a calculated average of 53 poults versus 43 for the controls. Although the overall reproductive performance of the turkeys under decreasing photoperiods was better than that of the controls, it cannot be said the method of preconditioning tested in this experiment was successful. (AH e3-18)

2. New turkey cage floor. An improved type of cage floor, designed to reduce egg breakage, was developed for use in turkey laying cages. The floor was constructed of flattened metal strips of flexible wire. The entire floor was then covered with plastic. Egg breakage following installation of this improved floor was reduced from a level of about 10% to less than one percent. Besides reducing egg breakage, use of these floors enjoys the added advantage of being easier on the birds' feet. The flat, closely spaced wires provide more surface area and this tends to reduce the incidence of calloused feet. (AH e3-19).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Physiology of Reproduction

- Healey, W. V., Russell, P. S., Poole, H. K., and Olsen, M. W. 1962. A skin grafting analysis of fowl parthenogens: Evidence for a new type of genetic histocompatibility. Ann. N. Y. Acad. Sci., 99, 698-705. (AH e3-20)
- Olsen, M. W. 1962. Polyembryony in unfertilized turkey eggs. J. Hered., 53, 125-128. (AH e3-19)
- Opel, H. 1961. Delay in ovulation in the hen following stimulation of the preoptic brain. Proc. Soc. Exp. Biol. and Med., 113, 488-492. (AH e3-15)
- Poole, H. K., Healey, W. V., Russell, P. S., and Olsen, M. W. 1961. Evidence of heterozygosity in parthenogenetic turkeys from homograft responses. Proc. Soc. Exp. Biol. and Med., 113, 503-505. (AH e3-20)

Environmental Physiology

- Marsden, S. J., Cowan, N. S., and Lucas, L. M. 1962. Effect of gradual and abrupt lengthening of photoperiod on reproductive response in turkeys. Poultry Sci., 41, 1864-1868. (AH e3-18)
- Olsen, M. W. 1963. Special floor reduces egg breakage in turkey laying cages. Poultry Sci., 42, 43-45. (AH e3-19)

POULTRY - NUTRITION
Animal Husbandry Research Division, ARS

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains and level of production. But, even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is ever to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships and interactions, it must be determined which portion of the diet is for intestinal microorganisms and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents, consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. There may be present growth promotant and/or inhibitors of which he is not aware.

USDA PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements and digestion and metabolism of poultry and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson. Studies concerned with the influence of different factors on the metabolism of vitamin A in chickens are in progress at the Hebrew University, Rehovoth, Israel. Its duration is for three years, 1962-1965, and involves PL.480 funds with \$29,527 equivalent in Israeli pounds. (A10-AH-7)

The Federal effort devoted to research in the poultry nutrition area totals 8.0 professional man years. Of this number 3.7 are devoted to nutritive requirements, 2.0 to digestion and metabolism, 1.9 to the nutritive values of feedstuffs, and 0.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutritive Requirements

1. Fat requirements. The performance of 3 groups of pullets--group 1 fed a fat-free diet, group 2 fed the fat-free diet plus lard, group 3 fed a standard laying diet--was observed for a 40-week period. This dietary treatment resulted in a partial unsaturated fatty acid depletion in groups 1 and 2.

The egg production of groups 1 and 2 was essentially equal and was considerably lower than that of group 3. The eggs laid by groups 2 and 3 were heavier than those of group 1 and the hatchability was also poorer in group 1. By the end of the experimental period, the time required for the hatching of the eggs of group 1 was prolonged about 36 hours beyond the usual hatching time. The major changes in the fatty acid composition of tissues resulting from the dietary treatments of groups 1 and 2 were an increase in the monosaturated fatty acids, oleic and palmitoleic, and a decrease in the polyunsaturated linoleic and arachidonic acids. There were no consistent changes in the fatty acid composition of the tissues of the pullets of groups 3. (AH e2-13)

Studies at Glendale, in cooperation with the University of Arizona, concerned with the effect of varying amounts of energy in laying diets, indicated that energy levels varying from 1150 to 1550 Cal/lb. of metabolizable energy had no effect on egg production. The efficiency of feed utilization increased progressively as the caloric content of the diet increased. The energy level in the diet had no effect on hatchability, and little effect on egg weight. Mortality was least on the lowest energy level and greatest on the highest level. (AH e2-15)

2. Protein and amino acid requirements. Studies with varying protein levels in growing and laying diets were continued using three commercial strains of White Leghorn chickens. Protein levels in the growing diets of 21 percent to 8 weeks of age, followed by 16 percent to 21 weeks, or 16 percent throughout the growing period, gave about the same growth and feed conversion, which was superior to that obtained with 16 percent protein to 8 weeks followed by 12 percent. When pullets from each of the growing diets were placed on 12, 14, 16, or 18 percent protein laying diets, the group which had received the 16 and 12 percent protein growing diet, and 12 percent protein laying diet, gave the poorest performance. The groups receiving the 14 percent protein laying diet produced as well as those on the 16 or 18 percent levels, regardless of growing treatment. The hens on the 12 percent protein laying diet produced smaller eggs than those of the higher protein levels. There was a strain difference in protein requirement for egg production. This phase of investigation is completed and future work will be concerned solely with amino acid requirements.

Preliminary studies concerned with supplementation of low protein diets with certain amino acids showed that when a 12 percent protein laying diet was supplemented with methione, lysine and tryptophan, there was an increase in production. Addition of the amino acid mixture to a 14-percent protein diet did not improve production. The amino acids did not affect egg size. (AH e2-16)

Studies at Glendale, in cooperation with the University of Arizona, showed the methionine supplementation of laying diets containing 1350, or 1450 calories of metabolizable energy per pound, had no effect on performance, whereas supplementation of a higher energy diet (1550C/ME/lb.) resulted in a slight improvement in egg production and feed conversion. The methionine-analog had no effect on egg size, hatchability, or mortality. Under the condition of the experiment 0.41-0.44 percent of methionine, plus cystine, appeared to be adequate for egg production. (AH e2-15)

3. Mineral requirements. In continuation of the study of calcium and phosphorus requirements of broiler chicks, a third test was conducted. This trial was with mixed sexes, and involved calcium levels of 0.7, 0.75, 0.80, and 0.85 percent, and total phosphorus levels of 0.45, 0.50, 0.55, 0.60, and 0.65 percent. Preliminary examination of the data indicated from 0-8 weeks a highly significant response to calcium, significant responses to phosphorus, calcium x phosphorus, and calcium x sex. At 4 weeks of age bone ash showed highly significant response to phosphorus and sex. Feed conversion was not significantly affected by any of the mineral levels at any age. The large volume of data from this trial is in the process of exhaustive statistical analysis, and it appears that a careful evaluation of the results of this and the two preceding trials will yield accurate values for the calcium and phosphorus requirements of broilers. (AH e2-18)

B. Digestion and Metabolism

1. Metabolism of fats. A study of the effect of a fat-free maternal diet on the growth rate and fatty acid composition of some tissues of the progeny showed that the depletion of the dams for 16 weeks did not affect the growth rate of the progeny. However, after the dams had been on the fat-free diet for 32 weeks the growth rate of the progeny was significantly depressed. As the depletion progressed, there was a reduction in the level of polyunsaturated fatty acids and an increase in monounsaturated fatty acids in the plasma and heart fat of day-old progeny. The level of linoleic acid decreased more rapidly than the arachidonic acid in these tissues. In the most severely depleted chicks, a rather high level of a C-20 triene was observed. The severity of depletion of the dams had no effect on the fatty acid composition of the tissues of the progeny after they had been fed a practical diet for 4 weeks.

A severe fatty acid deficiency was produced in the laying hen with recognizable symptoms, such as; extreme susceptibility to respiratory infection, and alteration in fat metabolism to produce in relatively large amounts an unidentified C-20 triene. Progressive severity of deficiency resulted in small egg size, prolongation of hatching time, together with a marked decrease in egg production, and eventually zero hatchability. When the depleted hens were fed purified linoleic acid, they recovered as completely and rapidly as those fed safflower oil which contains a number of unsaturated fatty acids. This is good evidence that linoleic is the only essential fatty acid. (AH e2-13).

2. Effect of additives on feed utilization. Studies were conducted at Glendale to determine the effect of furazolidone, oleandomycin, erythromycin thiocyanate, and the combination of procaine penicillin, and streptomycin on the performance of a high producing strain and a low producing strain of White Leghorn hens. All the data have not been summarized, but results to date indicate no effect on egg production or feed conversion with either strain (AH e2-13)

C. Nutritive Value of Feeds

1. Effect of feeding cottonseed meal or its constituents. In studies at Glendale in cooperation with the University of Arizona it was shown that feeding of cottonseed oil, together with crystalline gossypol, intensified the discoloration caused by gossypol in eggs cold stored for 1 or 3 months at 35°F. The cottonseed oil caused pink coloration in eggs.

Other tests indicated that oil dipping of eggs prevent yolk discoloration in stored eggs when the dietary level of free gossypol was less than 0.008 percent. Spraying with oil was effective at 0.001 and 0.002 percent levels of free gossypol when the storage temperature was 35°F., but not at 50-55°F.

Further studies showed that cottonseed oil at 0.1 percent level had no effect on yolk color of stored eggs, whereas 0.2 percent, or more, of cottonseed oil in the diet, and 3 mg/day, or more, of gossypol resulted in discoloration. Therefore, if the materials used in this study approximate the plant pigments and residual oil of cottonseed meal, it appears that laying diets containing less than 0.1 percent cottonseed oil and about 40 parts per million cottonseed pigments measured as free gossypol, would be satisfactory.

In tests to determine the carryover from feeding cottonseed meal to furnish 0.008 percent gossypol for the first 16 or 18 weeks of life, it was found that only slight discoloration appeared in relatively few eggs after 6 months storage. (AH e2-17)

2. Effect of calcium sources on shell quality. Tests conducted at Glendale showed that calcium gluconate in the diet did not improve whole egg weight, ratio of dried shell weight to whole egg weight, shell thickness,

or egg production over that obtained when ground limestone was the sole calcium supplement.

3. Fish solubles as a growth promoter. The results of an 8-year study showed that the addition of fish solubles to a practical diet adequate in all known nutrients, gave 6 percent increase in growth rate. When the data were summarized according to these periods (November through February), (March through June), and (July through October), analysis of variance indicated that year, period, dietary treatment, year x period and year x treatment effects were highly significant. The growth rate during the last three years of the study was significantly less than that of the preceding years. The response in November-February period was significantly higher than the other two periods. (AH e2-16)

4. Nutritive value of grains. Studies at Glendale, in cooperation with the University of Arizona, showed that when sorghum grains were compared with corn, the protein of three varieties was inferior and two varieties were equal to corn. However, when fed on an equal protein basis, one of these varieties was also inferior to corn. Supplementation with lysine did not improve the biological value of the sorghum grains.

Results obtained from a study of the effect of grains and corn oil on egg size, indicated that when chickens were maintained on diets containing corn, wheat plus corn oil or wheat plus lard from hatching through the first laying year, there was no consistent difference in egg size from the dietary treatments. These data are at variance with those published by other investigators. (AH e2-16)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nutritive Requirements

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Nutritive Value of Feeds

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POULTRY - IMPROVEMENT OF VIABILITY
Animal Husbandry Research Division, ARS

Problem. Leukosis continues to cause a higher mortality among chickens than any other disease. The yearly financial losses from leukosis mortality in the poultry industry of the United States are estimated to be in excess of \$65,000,000.00. At this time when the margin of profit is small, it is more urgent than heretofore that additional emphasis be placed upon research with the hope that control measures may be developed.

Leukosis is prevalent in both young and older stock, and on most, if not all farms, where chickens are raised. The incidence of leukosis among chickens is influenced by the genetic constitution of the stock and by environmental factors. There is great need for basic information on the natural history of neoplastic diseases of poultry including modes of transmission, and their relative importance, and environmental as well as other yet undetermined factors which influence the development of neoplasia among infected birds. Genetic testing of inbred lines of chickens for the different disease entities involved in the avian leukosis complex will assist in clarifying the total problem. Furthermore, it is apparent that the disciplines of biochemistry and biophysics must now be emphasized and integrated into the research program in order to hasten the development of control measures.

USDA PROGRAM

The basic and applied research is conducted by pathologists, bacteriologists, geneticists, and virologists at the Regional Poultry Research Laboratory, East Lansing, Michigan. Some of the studies have as their objective the biological and physical characterization of the agent or agents causing visceral lymphomatosis and related neoplasms of the leukosis complex. Research is also underway on the pathogenesis of the three primary types of avian leukosis and other related neoplasms for the purpose of determining and evaluating their etiological, pathological, and immunological relationships. Efforts are being made to develop more rapid and more precise methods of virus and antibody detection and assay; to determine and evaluate the importance of serum antibodies in the spread of infection; and the development of neoplasms. Such information is required for the development and effective use of a vaccine. Work is in progress on the development of a killed as well as an attenuated vaccine.

There are three phases of genetics work related to avian lymphomatosis. One involves the development and maintenance of inbred lines characteristically different in their resistance to lymphomatosis and related neoplastic diseases. One susceptible line is maintained in isolation to minimize infection with the disease. These lines provide relatively uniform experimental material for the study of nongenetic factors controlling disease expression and incidence. The second phase involves studies of the modes

of inheritance of genetic differences in resistance to lymphomatosis and related neoplastic diseases. An objective of the second phase is to find efficient ways of identifying chickens genetically resistant to lymphomatosis as expressed by low mortality under field conditions. The third basic phase of genetics research has as its objective the study of the mechanisms of genetic resistance to viral neoplasms. Research in the area of epizootiology has been greatly expanded. Much of this will be done with commercial flocks and with hatchery operators. Financial support for these studies is provided by both the National Cancer Institute, NIH, and the American Cancer Society.

A cooperative project entitled "Studies on the epizootiology of avian lymphomatosis and related neoplasms" calls for the active cooperation of (1) the Epizootiology Section, Epidemiology Branch, National Cancer Institute; (2) the Animal Disease Eradication Division, and the Regional Poultry Research Laboratory, Animal Husbandry Research Division, ARS; and (3) the American Poultry and Hatchery Federation. Cooperative projects also include work located in New Jersey, Pennsylvania, and Virginia. A research contract is still underway at the Wisconsin Agricultural Experiment Station.

The Federal scientific effort devoted to the research in this area totaled 9.4 professional man-years. Of this number, 3.0 are devoted to studies of the causative agent of avian lymphomatosis; 1.3 to improvement through genetic methods; 2.7 to improvement through vaccination, feeding and management practices; 1.0 to epidemiology of leukosis, and 1.4 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Studies of the Causative Agent of Avian Lymphomatosis

1. Characterization of field isolates of leukosis virus. The oncogenic spectra of five of the newly isolated strains of avian leukosis virus were investigated in the inbred line 15I chickens. Dosage level of the virus, age at the time of inoculation, and route of inoculation were all shown to influence, to a marked degree, the neoplastic response. There were differences in the spectra of the strains but the general response was similar to that induced by virus of strain RPL 12. Among the neoplasms induced were erythroblastosis, endotheliomas, fibrosarcomas, nephroblastomas, osteopetrosis and visceral lymphomatosis. In addition, hemorrhages were a common cause of death in chickens inoculated intravenously as embryos with large doses of viruses. Neural and ocular lymphomatosis were conspicuous by their absence. In further attempts to induce the neural disease these strains will be inoculated into chickens of line 7 which is known to be highly susceptible to neural lymphomatosis.

The JM strain of lymphomatosis has been reported to induce the neural and ocular as well as the visceral forms of lymphomatosis. This strain was made available to us by the Massachusetts Experiment Station. It was found that line 7 chickens are much more susceptible than line 15I chickens to the JM strain. This is the reverse of what has been consistently obtained for many years with all other chicken tumor viruses heretofore studied. The JM strain caused primarily neural and gonadal tumors in line 7, whereas in line 15I the tumors were similar to those obtained with strain RPL 12. Successful transmission was obtained with 7 of 8 cellular suspensions, 2 of 4 filtered extracts, 1 of 2 centrifuged extracts, and 1 serum sample gave a negative result.

It is apparent that the virus of the JM strain is quite different in several aspects than that of strain RPL 12 or of 10 other, but similar strains, isolated from field "outbreaks" of lymphomatosis. (AH e6-10 Rev.)

2. Virus propagation and tissue culture. The transformation of normal chicken embryo fibroblast to neoplastic cells by the Rous sarcoma virus (RSV) is the important part of the RIF test. It has been found that different strains of the RSV vary widely in the morphology of the transformed foci and in the type of cells comprising the foci. These characters largely determine the ease of recognition of transformed foci, hence certain strains of RSV are preferred in all tests requiring assay of RSV.

Studies on the validity of the RIF (resistant inducing factor) test, an indirect tissue culture method of detecting and assaying the lymphomatosis and other leukosis viruses, have continued. Selected tissues and extracts have been assayed for virus by the RIF and the chicken inoculation methods as well as by examination with the electron microscope. Good agreement by the three methods has been obtained for most samples. Discrepancies have been confined to the samples with a very low virus content.

The RIF method has been used to survey the laboratory flock of inbred, susceptible line 15I White Leghorns. A total of 450 embryos of 50 hens have been tested by the RIF method. A moderate percentage gave a positive result despite the fact that all of the hens were negative for antibody. Further studies indicate that most, if not all, of the "positive results" were actually falsely positive for RIF. They seemed due to genetic or innate resistance of the embryo cells to transformation by the Rous sarcoma virus rather than to the presence of lymphomatosis virus.

The demonstration of genetic resistance has far-reaching implication since many investigators have recently started to use the RIF test and the possibility of genetic resistance of the embryo cells has not heretofore been recognized. (AH e6-24)

B. Improvement Through Genetic Methods

The studies of genetic resistance to Rous sarcoma virus have been extended to investigate the effects of the single dominant gene for susceptibility on the response of embryos and cultures of embryonic cells exposed to this virus. The results suggest that this single gene affects in vitro as well as in vivo resistance to Rous sarcoma virus. A back-crossing program to the resistant line has been initiated to investigate the effects of this single gene on the ability to produce Rous sarcoma virus antibody susceptibility to lymphomatosis and related characteristics. (AH e6-2)

The genetic testing, and testing for the presence of virus and antibody in the isolated susceptible line of chickens has been increased largely due to the availability of new methods of virus and antibody detection. (AH e6-3)

Cooperative studies with the Alabama Experiment Station have shown that donor-host differences at the B blood group locus contribute to skin graft rejection and splenomegaly when adult cells are injected into embryos. It was also found that the A and C blood group loci play a relatively small role in skin graft rejection. Some skin grafts are accepted permanently when exchanged between members of the same inbred line, suggesting that progress has been made toward producing histocompatible lines. (AH e6-28)

C. Improvement Through Vaccination, Feeding and Management Practices

Studies on the measurement, interpretation, and function of circulating antibodies have continued. Extensive data have shown that serums which do or do not neutralize the induction of erythroblastosis also have the same effect on the induction of visceral lymphomatosis. These data provide convincing evidence that these two different neoplasms are caused by the same virus. Thus, the in vivo neutralization tests based on the more rapidly developing neoplasms, erythroblastosis, can be used with confidence in any immunological studies of visceral lymphomatosis. Tests with the induction of erythroblastosis can be completed in 45 days when 11-day embryos are inoculated; whereas, a test based on visceral lymphomatosis requires at least 245 days for completion.

Further work with the in vitro RIF test has provided additional data that shows excellent agreement between this tissue culture method and the in vivo chicken inoculation method. This is true not only for the detection and measurement of virus but also of antibody.

Additional data provide confidence in the use of the Rous sarcoma virus for the detection and assay of leukosis-lymphomatosis antibodies. In only a small percentage of the serums tested have there been disagreements between the Rous sarcoma virus and leukosis strain RPL 12 virus neutralization. Such low percentages of discrepancies are of no significance in field studies of the occurrence of leukosis antibodies. However, they are

important in studies of the antigenic relationship between the various chicken tumor viruses. It would appear that the Rous sarcoma virus is antigenically quite similar but has important differences from all of the leukosis viruses that have thus far been isolated and studied.

Research on the improvement of the complement fixation test for the detection of leukosis and other tumor antibodies has continued. Variations in antigen preparation, incubation periods and concentration of the several complement components have been tested. No material increase in sensitivity has thus far been obtained.

The genetic constitution of the host and the amount or exposure dose of virus have been found to largely determine the immunological response. The route of infection, the age at the time of exposure, the immune status at the time of exposure, and the type of virus strain are additional factors which will be studied to assess the interrelationships and their influence on the immune response. Data thus far obtained with viruses of strains RPL 12 and RPL 29 have revealed that the induction of the immune response is closely correlated with respect to amount of virus to the induction of neoplasia. Untreated virus at high doses caused erythroblastosis and antibodies in almost all birds at about the same time. Moderated doses that cause visceral lymphomatosis after about 5 months have resulted in a high percentage with antibodies within 2 months.

Studies of virus preparations treated with various concentration of formalin or Beta-propiolactone have shown that relatively large amounts of these inactivating agents are required to eliminate the oncogenic potency of the RPL viruses. With a decrease in oncogenic effect there was also a decrease in the immunity (antibody) response, thus indicating that inactivated virus had by itself little antigenic activity.

Other virus strains, routes of infection and the use of adjuvants will be tested in attempts to obtain a good immune response. (AH e6-17 Rev.)

D. Epidemiology of Leukosis

Four field studies are now in progress. None has been completed though the following observations have been made: (1) maternal Rous sarcoma virus antibodies have no major influence on occurrence of leukosis later in life; (2) the incidence of leukosis and occurrence of RSV antibody in adults is positively correlated; and (3) line 15I chickens under natural conditions of exposure have developed as high an incidence but require a longer time to death than chickens of some commercial sources. (AH e6-27)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Studies of the Causative Agent of Avian Lymphomatosis

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POULTRY - ENVIRONMENT AS RELATED TO BROILER LOSSES
Animal Husbandry Research Division, ARS

Problem. Effective control of Air Sac Disease to reduce the continuing losses from condemnations is a major problem of the broiler industry. Since the presence or absence of pathogenic strains of the pleuropneumonia-like organism, *Mycoplasma gallisepticum*, largely determines whether chickens will develop Air Sac Disease in the presence of secondary invaders, such as *E. coli*, Newcastle disease or infectious bronchitis, the value of effective methods for control is evident. Additional basic information is needed concerning the behavior of the organisms associated with this disease complex and the host response to them. The great range in host response indicates that genetic variation, nutrition, environment, and management play a part in the severity of the response in individual flocks of chickens.

USDA PROGRAM

A basic and applied program of research directed toward the reduction of losses from broiler condemnations is to be conducted jointly by specialists in agricultural engineering, poultry management, disease, genetics, nutrition, and physiology. Two locations are involved in this work, the Southeast Poultry Research Laboratory, Athens, Georgia, and the South Central Poultry Research Laboratory, State College, Mississippi.

The Animal Husbandry Research Division's work at Athens emphasizes genetics and physiology in relation to the Air Sac Disease complex and the work at State College will emphasize environment and management in relation to condemnation losses.

This research program is cooperative with the Animal Disease and Parasite and Agricultural Engineering Research Divisions, ARS. Local cooperation of State experiment stations and the broiler industry in the southeast and south central regions is an important part of the program, particularly with respect to field trials.

The Federal effort devoted to research in the poultry management area totals 2.2 professional man-years. Of this number 1.0 is devoted to genetics in relation to airsacculitis, 1.0 to management in relation to condemnations, and 0.2 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics in Relation to Aairsacculitis

The Southeast Poultry Research Laboratory was dedicated on June 1, 1963, and is not yet fully operational. The program is just getting underway.

B. Management in Relation to Condemnations

No method of egg dipping offered sufficient promise of being of practical value to broiler raisers to justify further field trials.

Although management factors appear to be important in the development of airsacculitis, successful investigation of these factors requires almost constant observation on individual farms, because of the close supervision of unskilled operators required.

The use of a dried culture of *Bacillus megatherium* was tried on six farms with over 21,000 broilers and an equal number of untreated controls. No favorable value was observed. None of the various treatments to control avian nephrosis have been effective. Treatments have included antibiotics, vitamins, sulfamethazine, molasses, and disinfectants.

Installation of partitions in order to reduce drafts have been effective in raising broiler house temperatures in cold weather. (AH e7-1)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None

INFECTIOUS AND NON-INFECTIOUS DISEASES OF POULTRY
Animal Disease and Parasite Research Division, ARS

Problem. Annual losses from infectious and non-infectious diseases of poultry, exclusive of parasitisms, are estimated to be at least \$200 million. Continued and expanded basic and applied research are essential to aid in reducing these losses, which inevitably affect cost to the consumer. Added to the initial losses from mortality, reduced weight gains, poor feed utilization, decreased egg production, and lowered quality, are the final losses occasioned by condemnations at dressing plants. Since institution of compulsory inspection for interstate movement of poultry and poultry products, overall condemnations because of disease have skyrocketed. The problem is to keep abreast of changing conditions in the field, which present increasingly complex problems requiring basic information.

USDA PROGRAM

The Department has a long-term program involving biochemists, microbiologists, pathologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of infectious and non-infectious diseases of poultry. Research is being conducted on the diseases at the following locations.

The Federal scientific effort devoted to research in this area totals 31.4 professional man-years. This effort is applied as follows:

Ornithosis 5.1 at the National Animal Disease Laboratory, Ames, Iowa, and under cooperative agreements with the Universities of California and Minnesota, and the Agricultural Experiment Stations of Oregon and Texas.

Salmonellosis 3.0 at the National Animal Disease Laboratory, Ames, Iowa.

Pasteurellosis 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Chronic Respiratory Disease Complex 16.7 at the National Animal Disease Laboratory, Ames, Iowa, the Southeast Poultry Research Laboratory, Athens, Georgia, and under cooperative agreements with the Agricultural Experiment Stations of Connecticut, Delaware, Georgia, Massachusetts, New York, North Carolina, Texas, Virginia, and Wisconsin, and with the University of Minnesota. A basic project on chronic respiratory disease is in progress at the Hebrew University, Jerusalem, Israel, under a PL 480 Grant of funds equivalent to \$29,189 over a 3-year period.

Newcastle Disease 4.2 at the National Animal Disease Laboratory, Ames, Iowa, the Southeast Poultry Research Laboratory, Athens, Georgia, and under cooperative agreements with the University of Maine and the Wisconsin Agricultural Experiment Station.

Bluecomb 0.1 under contract with the University of Minnesota, St. Paul.

Leukosis 0.3 under cooperative agreement with the Regional Poultry Research Laboratory, USDA, East Lansing, Michigan.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Ornithosis

Cooperative studies at the University of California showed that chickens, inoculated with ornithosis virus by different routes, failed to show signs of the disease during 4 weeks, but 65 percent of them produced complement-fixing antibodies at a low level. The virus was isolated from the spleen and liver from only one bird 4 weeks after inoculation. It was observed that not all ornithosis yolk sac antigens showed the same antigenic characteristics to fix complement with avian serums in the Brumfield's DCF test. One antigen (YS-10) that inhibited the reaction, was not affected by heat-treatment such as 56° or 100°C for 30 minutes.

A modified ICF test was conducted using rabbit immune serums as an indicator positive serum in place of human or pigeon serums. Relatively high correlation was obtained between the modified ICF and the Brumfield's DCF tests using chicken and turkey serums.

An antibody titer in the Brumfield's DCF test was affected by individual normal chicken serums normally added to the system, but 3 times concentrated normal chicken serum was not always required by chicken antigen-antibody complexes in the Brumfield's DCF test. (California)

Cooperative work at Minnesota indicated through serologic evidence, that the ornithosis entity remains prevalent in the avian population, particularly in turkeys. A field outbreak occurred on one farm involving two breeder flocks. Clinical, fluorescent antibody, serological and pathological findings were confirmed by virus isolation in embryonated chicken eggs and mice. A younger flock, six weeks of age, on the same farm never developed serological or clinical evidence of the disease.

A very good correlation between parallel tests with a bacterial extract antigen and the ornithosis antigen on large numbers of experimental and field cases has been obtained. Antibody titers could apparently be detected earlier with the bacterial antigen. The substitution of this antigen for the ornithosis virus in the DCF test could lessen the human hazard of infection and make available a simple test for use in more laboratories.

Fluorescent antibody techniques and hypersensitivity reactions indicate that both show promise as aids in the diagnosis of ornithosis.

Free flying birds tested for ornithosis antibodies have given negative results.

A cooperative study with the School of Public Health to evaluate the prevalence of DCF titers of people working on premises with turkeys has been conducted. Five and one half per cent of the individuals have suspicious titers with less than 0.5% with positive titers. On these farms, 10.6% of the turkey flocks were considered positive by the DCF test while 4.6% of the flocks showed suspicious titers. (Minnesota)

In cooperative work at the Oregon Agricultural Experiment Station, an ornithosis isolate of sea gull origin (G1) found to be highly pathogenic to turkeys, white mice and chicken embryos, was propagated by serial passage in two cultural systems, white mice and chicken embryos. The pathogenicity has increased for mice to the degree that it is killing them in 3 days, whereas earlier passages would kill in 5-6 days. The pathogenicity for chicken embryos has been quite erratic and there is no indication of increased pathogenicity at the 18th passage.

Year old Beltsville white turkey hens were challenged with the 10th and 20th serial mouse passage and the 10th serial chicken embryo passage. Each hen received 1.0 ml. of a 10% infected tissue suspension inoculated intramuscularly. The results showed that the 10th and 20th mouse passages were very pathogenic for turkeys at the dosages given. The 10th embryo passage was less pathogenic for turkeys.

Beltsville white turkeys have been immunized by exposure to a live culture of ornithosis virus of low toxicity (T3). A mild clinical response resulted from this exposure but no viremia could be demonstrated. Serologically there was a transitory reaction to Mycoplasma gallisepticum antigen 13 days postinoculation. After 27 days the birds were negative to this antigen. Ornithosis challenge with the highly pathogenic G1 isolate at 4, 7, 10, and 18 months postimmunization did not produce any clinical response or demonstrable viremia. The T3 isolate has been serially passed 16 times in mice with no evidence of any increase in pathogenicity. The isolate will infect mice but deaths occur only sporadically. Attempts to serially pass this isolate in chicken embryos have not been successful. (Oregon)

At the Texas Agricultural Experiment Station, in research work during the year, turkey ornithosis antiserum of high titer collected at various intervals after infection, was fractionated by three methods. Methods of fractionation were column chromatography, sucrose gradient ultra centrifugation and starch electrophoresis. All fractions were run by the three recognized serological tests for complement fixing antibody (indirect complement-fixation (ICF), Benedict direct complement-fixation (BDCF), and Brumfield direct complement-fixation (Br DCF).

The starch electrophoresis and sucrose gradient fractionization show that the ICF test is measuring principally a fast moving heavy antibody, whereas the DCF tests are measuring a slow moving light antibody.

Swine of various ages were refractory to ornithosis virus. This species is the first one that has not been susceptible to this agent. It is interesting to note that no lymphogranuloma venerum group agents have been isolated from swine.

Sheep (ewes) were susceptible to ornithosis when inoculated, but transmission did not occur from infected turkeys to normal sheep. (Texas) (ADP a5-20)

B. Chronic Respiratory Disease Complex

At the National Animal Disease Laboratory, Ames, Iowa, the following studies have been conducted: a) comparison of the effects of turkey Mycoplasma gallisepticum infection produced by intranasal inoculation, intratracheal inoculation and contact with inoculated turkeys; b) serological studies of Mycoplasma (PPLo) of avian origin.

Under a) above, research was conducted with Mycoplasma gallisepticum to compare effects of intranasal, intratracheal and pen contact exposure in turkeys maintained free of environmental stress. Clinical signs of infection, as indicated by coughing or tracheal rales, appeared 3 weeks after exposure and reached a peak during the 6th week when signs were observed in 70% of the birds. Antibodies for M. gallisepticum, as determined by weekly tube agglutination tests, were first demonstrated 4 weeks after exposure, and were present in all turkeys by the 7th week.

Periodic postmortem and bacteriological examination of turkeys during the course of the infection revealed that M. gallisepticum could be isolated without difficulty from trachea, lungs and air sacs until 10 weeks after exposure. None were isolated after 10 weeks. With the exception of one turkey examined early in the course of the infection, all turkeys had air sac infections. Only one turkey out of the group of 28 developed a sinusitis, and only two developed secondary bacterial infections (Escherichia coli). No differences in clinical signs, lesions, or serological response were produced by using three different methods of exposure.

Under b) above, nineteen strains of PPLo of avian origin were classified serologically into 7 groups on the basis of the tube agglutination and growth inhibition tests. The three strains, S-6, F, and PG-31, associated with chronic respiratory disease of chickens, comprised a single serological group and could be distinguished from the other strains by the serological tests.

The serological studies were done in two series of experiments. In the first studies, antisera were produced in rabbits by inoculating 6 to 10 times with PPLo antigens. The 19 PPLo strains were then grouped serologically using the tube agglutination test. In the second part of the studies, growth inhibiting antisera (requiring from 10 to 40 inoculations) were produced in rabbits. The 19 PPLo strains were grouped again serologically

using both the tube agglutination and the growth inhibition tests. Discrepancies between the two sets of antisera were observed. The more hyperimmune sera of the second studies were considered more reliable for grouping the PPLO serologically. The tube agglutination and the growth inhibition tests appeared to be of equal value where the more hyperimmune antisera were used, although neither test alone was completely reliable.

Growth inhibition and agglutination appeared to be separate activities in the antiserum complex. (ADP a5-21)

At the Southeast Poultry Research Laboratory, Athens, Georgia, the following work has been done:

Fluorescent Antibody Studies with Infectious Bronchitis Virus.

Promising results have been obtained with the fluorescent antibody (FA) technique applied to infectious bronchitis virus (IBV). Infected tissue cultures and tracheal sections fluoresce brightly with laboratory and field strains of virus. Cross reaction with Newcastle disease virus has not been observed. The FA technique was demonstrated to be sensitive enough to follow the growth cycle of IBV in tissue culture. This application will be useful in studies to adapt field strains of virus to growth in tissue culture.

Cultivation of Infectious Bronchitis Virus in Tissue Culture.

While the egg-adapted Beaudette strain of infectious bronchitis virus is readily grown on chick kidney cell cultures, attempts to adapt field strains of this virus to tissue culture have not succeeded beyond the 5th passage. However, by use of fluorescent antibody techniques some evidence of infection has been demonstrated with selected field strains.

Improved Culture Media for Growth of Mycoplasma Gallisepticum (S6 Type).

An improved culture medium for growth of Mycoplasma gallisepticum was developed. Using brain heart infusion as a base, the optimum levels of various growth additives were determined and incorporated in to the medium. Experiments on buffers showed maximum growth was obtained using Tris buffer rather than phosphate buffer. The effect of various inoculum concentrations on the volume of the resultant cell crop was subsequently determined.

Mycoplasma Gallisepticum Antigen Production.

Sufficient plate antigen was produced during the year to conduct 336,000 tests. In addition to use in our own research program, the Georgia Poultry Diagnostic Laboratory, Gainesville, has been supplied with over 250,000 test doses.

Chronic Respiratory Disease Control Program.

Condemnations due to airsacculitis were 13 times greater in progeny from a *Mycoplasma*-positive flock than from a *Mycoplasma*-free flock. Similarly, the *Mycoplasma*-free progeny had the best liveability, lowest mortality, highest average weight and lowest cost per pound. Feed conversions in the two groupings were identical. Over 100,000 broilers were involved in this detailed field study. This study demonstrated that replacement flocks can be reared and maintained in a *Mycoplasma*-free status in poultry houses with dirt floors. (Athens, Georgia, Research Laboratory)

Cooperative studies at the Connecticut Agricultural Experiment Station on several phases of work gave the following results:

Serology. Antigen for testing avian whole blood or serum for antibodies to *Mycoplasma gallisepticum* (PPL0), was produced under AIQ special license number 237 and sent to 64 research workers in 30 States, and 22 workers in 17 foreign countries. Because of the increased demand, this Station produced 520,000 doses during the past year, better than a 100% increase over the previous year (228,000 doses).

This laboratory has continued to survey the incidence of PPL0 infection (*M. gallisepticum*) in poultry flocks in Connecticut in conjunction with the official *Salmonella pullorum* test and has found the majority of these flocks to react positively to our *M. gallisepticum* antigen, indicating a high rate of flock infection in Connecticut.

Control. Eight-week-old chicks were inoculated with live pathogenic *M. gallisepticum* and performance as regards growth rate, hatchability, fertility, egg production, mortality, etc., was compared to a control group. The immunized birds performed as well as the non-infected group, showing that, provided birds are vaccinated at the proper age and the infection is not complicated by other respiratory diseases, no harmful effects occur. At 23 weeks of age *M. gallisepticum* could not be isolated. In addition, upon challenge at 23 weeks with a pathogenic *M. gallisepticum*, no organisms could be isolated from the trachea or air sacs one week post inoculation. *M. gallisepticum* was readily isolated from a control group which was not previously immunized.

The inability to isolate *M. gallisepticum* after birds have recovered suggests that this procedure may eventually be adapted to an eradication program.

Isolation. A simple technique for isolation of PPL0 from contaminated material has been devised using membrane filters (Millipore Filter Corp.) of 0.45 micron pore size. Material is suspended in broth and filtered using a syringe and Swinney adapter to hold the filter.

Using this technique *M. gallisepticum* has been isolated from feces and

litter from birds showing active symptoms of CRD. This procedure is well adapted to searching for PPLO which might be involved in diseases of unknown etiology. Present techniques of virology are inadequate since high levels of antibiotic are used which might inhibit growth of PPLO.

Nutrition and Physiology. In a basal medium consisting of tryptose, glucose and PPLO serum fraction (Difco) it was found that addition of Tris buffer and bovine hemaglobin increased the cell growth (Optical Density) by 30% which is of considerable importance in terms of producing antigen.

On blood agar plates, M. gallisepticum produced beta hemolysis of bovine blood agar. The hemolysis, however, does not appear to be related to pathogenicity since a strain of M. gallisepticum, which produces no disease in chickens and is unable to kill chick embryos, also produced beta-hemolytic zones.

In chemical studies of M. gallisepticum, several lipid fractions were identified. These were: saturated hydrocarbons, cholesterol, cholesterol esters, di- and triglycerides, free fatty acids, and 5 phospholipids. Using radioactive C^{14} oleic acid and P^{32} orthophosphate as tracers, it was shown that cholesterol esters, di- and triglycerides and phospholipids were synthesized from simpler compounds. (Connecticut)

Cooperative research on chronic respiratory disease at the Delaware Experiment Station during the year 1962-63, has been concerned with further studies on problems involved in the treatment of hatching eggs for the control of PPLO, an evaluation of various hatching egg treatments for PPLO control in broilers and the maintenance and serological study of the progeny of PPLO infected and free parents.

Attempts to provide a visual method of estimating the amount of antibiotic that enters an egg based on the previous observation that food dye will show up on candling soon after treatment have been made. There was good correlation between amount of dye and antibiotic content in white shelled eggs. However, with brown shelled eggs, detection of the dye was more difficult. The possibility exists of using this dye indicator system to eliminate eggs containing too little antibiotic in critical work aimed at eliminating PPLO.

Treatments of the egg shell with dilute acid to accomplish removal of the cuticle resulted in an enhancement of antibiotic absorption and bacterial contamination. On the other hand, shell thickness appeared to have no influence on drug absorption.

Work with bacterial contamination of eggs during the treatment process has established that bacterial entrance into an egg is enhanced in a similar fashion to drug absorption. The use of Hyamine 3500 was effective in controlling bacterial contamination with a Pseudomonas sp. and fungal contamination with an Aspergillus sp.

The antibiotic, Tylosin, was not effective in eliminating PPLO infection when administered at a 3 gram per gallon level for the first 5 days of life.

Several methods of treating hatching eggs and young chicks for the prevention of PPLO infection were without benefit when used on eggs and chicks from commercial sources in Delmarva. The level of PPLO infection was apparently absent or low in these experiments and this may represent a common occurrence under field conditions. This questions the need for routine preventative medication in broiler flocks.

High levels of chlortetracycline (1200 gms. per ton of potentiated feed) significantly lowered the number of birds reacting positively to the PPLO plate test and greatly reduced air sac lesions in birds experimentally infected with PPLO, E. coli, and infectious bronchitis virus.

A small flock of White Rock chickens has been maintained serologically free of PPLO for 40 weeks. They are being housed in an area near birds that are serologically positive. Under these conditions, the PPLO free flock averaged 7 eggs per month per bird more than those birds that are serologically positive. (Delaware)

Results of cooperative studies at the Georgia Agricultural Experiment Station tend to affirm that "PPLO-free" broiler chicks are able to withstand field (natural) exposure to CRD during the growing period and come through with a low incidence of air sac condemnation. This, however, cannot be assumed as a panacea for the problems of the broiler industry. Certain paramount responsibilities rest upon the broiler producer, viz:

1) There is no substitute for careful and well-planned management programs. The use of so-called "PPLO-free" chicks is no license to regress into poor and irresponsible management. With the investment in this breeding stock behind them, it behooves the hatchery organization to place these chicks with their best growers.

2) Vaccination programs normally used with PPLO-infected broiler chicks must be re-evaluated in terms of the "PPLO-free" chick's response.

3) Since "PPLO-free" breeding flocks are raised and maintained under more rigid control and management programs than normally followed for commercial broilers, the birds may not become naturally exposed to various "field" strains of infectious bronchitis virus. Susceptibility of their progeny to field strains must, therefore, be taken into consideration when setting up a vaccination program. (Georgia)

Cooperative research at the Massachusetts Agricultural Experiment Station yielded the following:

Properties of the agent (viability studies). The viability of 2 strains of Mycoplasma gallisepticum, virulent Hy and modified virulent, Adler-S6, is

influenced by the following factors: concentration of organism, temperature of storage, and the nature and quantity of suspending medium. The materials seeded with pleuropneumonia-like organism (PPLo) included the following: PPLo broth, Grumbles' media (5 carbohydrates), PPLo agar, saline, chicken serum, egg albumen, egg yolk, infertile eggs, chicken muscle, cloth, chicken feces, and feather meal. The viability of the PPLo in the various test materials is given as a range at the different temperatures of storage: 37 C, 1 day to 45 weeks; 20 C, 1 day to 7 weeks; 6 C, 1 day to 17 weeks; and -20 C, less than 1 week to 78 weeks.

Transmission. A group of 16-month-old asymptomatic hens that had experienced a natural outbreak of CRD prior to 3 months of age transmitted the disease to susceptible yearling hens by cohabitation; that is, direct contact transmission. The period of exposure was limited to 65 days, the duration of the experiment.

Serology and Immunity. Yearling hens that have undergone a natural outbreak of CRD at an early age manifested definite resistance to challenge inoculation with a pathogenic PPLo; whereas, susceptible controls exhibited typical signs and lesions of the disease. Varying levels of CRD agglutinins may be manifested in progeny of positive parent stock, and may persist for as long as 18 days post-hatching. This parental agglutinin test may have some diagnostic significance in detecting CRD-infected flocks.

Response of CRD to medication. The performance of CRD-infected chickens following medication with high levels of Tylan in the water or Tylan injectable was superior to that of the infected-nontreated birds.

Control and eradication. CRD-free stock can be reproduced and maintained if adequate sanitation and management practices are observed. The majority of negative premises continue to remain negative year after year. Some flocks have remained negative for 4 or 5 successive years. There is an increasing interest on the part of flock owners in CRD-free progeny. (Massachusetts)

In cooperative studies at the University of Minnesota, a whole blood plate antigen for the testing of chickens for M. gallisepticum was developed. This antigen has been used to test 51,000 chickens in 29 flocks. Five of these flocks contained reactor birds with an average incidence of infection in these flocks of 579.

Several criteria have been used to classify avian Mycoplasma strains. Growth-inhibition by specific hyperimmune sera, hemagglutination activity, hemolytic activity and carbohydrate fermentation were used to analyze 62 avian Mycoplasma isolates. Thirty-six of these have been shown to be Mycoplasma gallisepticum.

The incidence of airsacculitis in day-old turkey poults was determined in 1197 poults. The average incidence was 24%. In an attempt to locate "Mycoplasma free" poults, several lots of poults from different hatcheries

were examined. A flock of Jersey Buffs was found to be free of detectable *Mycoplasma*. Poults from this flock were raised in isolation for experimental studies. In addition Tylan^(R) was used in an attempt to produce "Airsacculitis free" turkey poults. Three poults of 557 examined from Tylan dipped eggs have shown airsacculitis, whereas 12 of 102 poults examined in the undipped controls had airsacculitis. This method of reducing airsacculitis will be further evaluated during the coming year.

Field investigations on 17 clinical outbreaks of infectious sinusitis were conducted. Contact with infected chicken flocks or other fowl and an outbreak in a turkey breeder flock were thought to be the possible source of the infection in some of the flocks.

Studies were continued on the effect of environmental conditions on artificial *Mycoplasma gallisepticum* infections. Two experiments were conducted with half of the birds held under what were felt to be near ideal temperatures, while the other half were held at lower temperatures. In both experiments the condemnation rate was higher in the groups held at the higher temperature, but the feed efficiency was lower under the cold environment so that the possible net profit would be lower.

Air samples were taken in hatcheries and on turkey farms in an attempt to quantitatively determine the microflora present. Large numbers of *Staphylococcal* sp., *Bacillus* sp., *Alkaligenes* sp., *Proteus* sp., *Pseudomonas* sp., *E. coli*, and *E. freundii* were found. The significance of these findings is unknown at the present time. Attempts are being made to correlate these findings with the organisms isolated from the air sacs of birds living in the same buildings.

The experimental control program on infectious sinusitis was continued on the basis of a 100% test of all turkey breeder flocks in the State and a flock inspection program of selected flocks in every hatchery. All indications are that infectious sinusitis continues to be held at a very low level in the turkey breeder flocks and their progeny. (Minnesota)

In cooperative studies conducted at the New York Agricultural Experiment Station, these results were obtained:

The presence of air sac lesions and the isolation of PPLO not *M. gallisepticum* from day old poults indicates a causal relationship. Furthermore, this evidence points to the egg transmissibility of the turkey strains of PPLO. The persistence of these organisms and lesions for many weeks in growing turkeys has been noted. Although this infection has not been associated with sinusitis in the birds studied, the air sac lesions may be confused with *Mycoplasma gallisepticum* infection. The serums of these turkeys do not agglutinate *M. gallisepticum* antigen. The attempt will be made to find poults free from this infection to initiate pathogenicity studies.

Dipping of eggs infected with Mycoplasma gallisepticum in solutions of Tylosin resulted in the hatching of non-infected chicks (with one exception) as proven by cultural methods. Such chicks when grown to maturity continued to be serologically negative (with exception of one group from eggs dipped in Erythromycin) when the agglutination test was applied. In contrast, non-dipped eggs produced infected chicks demonstrated by culture methods and persisted as serologically positive to maturity. A second generation of chickens hatched from eggs produced by dipped egg and un-dipped egg derived hens, were all serologically negative. It is clear that clean stock can be derived from infected dams by the egg dipping technique. It is equally clear that serologically positive dams need not necessarily produce infected progeny.

Inoculation of young chickens intra air sac with virulent Mycoplasma gallisepticum protected the birds completely from transmitting the organisms through the egg when the same birds were challenged at maturity. The degree of protection varied directly with the virulence of the immunizing cultures. Immunizing cultures of moderate to low pathogenicity induced a significant degree of resistance to later challenge but the protection was not complete.

Attempts are being made to determine whether serologically positive (M. gallisepticum antigen) birds can transmit M. gallisepticum to susceptible chickens by contact. Also experiments are in progress to determine whether the presence of cultivable M. gallisepticum from tracheal swabs is a better criterion for detection of spreaders. Tentative results indicate that contact transmission of M. gallisepticum need not occur even though serologically positive birds (from in ovo infection) and culturally negative are in contact with completely susceptible birds. On the other hand, in one trial the opposite result was obtained although in this case the serologically positive birds had been infected 16 weeks prior to contact with susceptibles. It appears that the efficiency of cultivation techniques for isolation of M. gallisepticum from tracheal swabs leaves much to be desired. (New York)

Cooperative studies at the North Carolina Agricultural Experiment Station have been made on quantitative and qualitative blood studies in relation to disease susceptibility of chickens experimentally infected with respiratory disease viruses, with special reference to in vitro and in vivo determinations of anti-E. coli activity.

Plasma influence on the bird's total resistance to E. coli appears to be relatively small since in vivo tests involving homologous and heterologous treatment of E. coli organisms and subsequent bird inoculations offered only slight differences in protection to the inoculated birds. (North Carolina)

Cooperative studies have been conducted at the Texas Agricultural Experiment Station with the following results:

Infectious Sinusitis Eradication Program. One hundred-eighty (180) breeding flocks, representing 217,017 birds and approximately 80 percent of the turkey

breeding stock in Texas, were enrolled in the 1962 program. Random sample (10 per cent) testing was used. Five M. gallisepticum infected flocks were identified and marketed.

Chronic respiratory disease control. A small replacement breeder flock was hatched from eggs produced by known M. gallisepticum infected breeders. The eggs were dipped in chilled antibiotic solution prior to incubation. The replacement flock is now in peak production and apparently free of CRD.

Attempts are being made to bring a large commercial breeder flock (20,000 birds) into production free of CRD. The birds, progeny of M. gallisepticum free breeders, were free of infection when 10 weeks of age.

M. gallisepticum antigen. Further refinement of M. gallisepticum antigen and antigen production techniques were made.

PPLO serotyping. Preliminary studies on the use of a cytopathogenic effect-inhibition (CPE-I) technique to serotype PPLO in tissue culture system were made.

Wildlife reservoirs of M. gallisepticum. Thirteen wild turkeys were serologically examined for evidence of M. gallisepticum infection and were found to be negative. (Texas)

Cooperative work at the Virginia Agricultural Experiment Station on the CRD complex was directed toward the defense of the chicken to one of the most commonly found bacteria in air sac infection, E. coli. A unique approach was employed to arrive at the determinations made - a continuous-flow intravenous inoculation of the bacterial culture over a 24-hour period, or throughout a 14-day period. The pathogenic bacteria were given at the rate of 10 million to 1 billion organisms daily for 1 - 14 days. A separate hookup for taking electrocardiograms was also maintained.

From 8 minutes to 6 hours or 1 day after the beginning of continuous inoculation the blood cultures were maintained at about 100-300 bacteria per ml. The lymphocyte counts steadily fell until 12-24 hours when they virtually ceased to be present till the 3rd day when they slowly increased in number. The heterophile blood counts reached a low level at about 1 hour after which they rose to from 30,000 or 60,000 in birds that resisted pericarditis. The rise in heterophile counts preceded a period of complete clearing of the blood of bacteria which occurred between 6 and 24 hours after the beginning of bacteremia and continued for 6 hours to 3 days. In birds which developed pericarditis the period of complete clearing was very short and the rise in heterophiles to 15,000 per ml was of short duration. Eventually the high heterophile counts of birds which did not develop pericarditis fell and the period of complete clearing of the blood came to an end. After this fall the blood contained from 500-5,000 bacteria per ml and the heterophile count rose to very high levels. After the 7th day the blood culture level fell in association with a rise in the lymphocytes count.

Body temperature tended to remain normal but often rose to 108°F just before death. Plasma albumin often became drastically reduced as exposure progressed. Gamma globulin rose during the course of exposure.

By means of an electrocardiogram it was possible to detect the onset of pericarditis.

The reaction of the chicken to continuous intravenous exposure seemed to be considerably different from the reaction to a single dose. It appears that pericarditis must occur early in the period of exposure or not at all.
(Virginia)

Cooperative work at the Wisconsin Agricultural Experiment Station has been directed to studies on measuring the environment of turkeys raised in confinement. Three experimental flocks of turkeys have been reared in the Meteoropathology Building. The primary emphasis has been placed on methods for study of the influence of environment on respiratory diseases of turkeys.

Temperature, humidity, atmospheric dust, ammonia and carbon dioxide, light intensity, sound, bird activity, water consumption, feed consumption, bacterial content of the air and litter, moisture content of the litter, are some of the factors being measured. Birds are regularly removed and sampled for disease organisms. Mycoplasma, staphylococcus and unidentified viruses have been recovered. The relationship of mycoplasma isolated, which is not of the S6 type, to N type is under study. The presence of this organism appears to be causally related to clinical air sacculitis. Techniques have been perfected for the recovery of mycoplasma from aerosols. The half life of the organism in the air and the biology of transmission is being studied.
(Wisconsin) (ADP a5-17) (ADP a5-21)

C. Newcastle Disease

In cooperation with the Wisconsin Agricultural Experiment Station, current research on Newcastle disease virus was evaluated at an International Symposium held in Madison July 15, 16 and 17, 1963. Much of the planning for this event was undertaken by the Wisconsin staff. Important questions unresolved are interepizootic persistence, mechanisms of transmission, nature of virulence, evolution of new antigenic strains.

Previously we have shown that chicken virulence and time of embryo death can be related. It now appears that plaque morphology may also be related to virulence. Virus (Herts strain) of the large clear plaque type induces severe hemorrhage in embryos and rapid death, whereas virus of the small plaque type isolated from the same strain fails to induce hemorrhage and kills after a prolonged incubation. Virulence characteristics of all plaque types are under study.

Other work concerns development of avian cell lines, evaluation of serological methods for antigenic analysis of strain differences, and quantitative studies of NDV aerosols. (Wisconsin)

In cooperative work at the University of Maine, the evaluation of killed Newcastle disease vaccine in chickens is in progress. A specific pathogen free (SPF) program has been conducted on broiler and breeder flocks during the past year - 1962-63. A rigid set of standards for isolation and husbandry are required to conform to the program. A total of 20 SPF breeding flocks, comprising 70,960 birds, have been on the program. Approximately 142,654 samples have been tested for PPLO. A method of mass testing (tube agglutination) has been developed.

A total of 65 SPF broiler flocks, totaling 1,502,862 birds, with an average weight of 3.78 pounds at 9 weeks of age, have been processed. Forty-six flocks have been free of infectious bronchitis; 34 of PPLO and 62 of Newcastle disease.

Approximately 4 million doses of dead Newcastle disease vaccine have been used in the State of Maine this year with no evidence of "breaks." (Maine) (ADP a5-18)

Work at the Institute of Veterinary Research, Pulawy, Poland, under a PL 480 grant, has shown that thirty passages of virulent NCD virus through chickens infested with roundworms, and through chickens previously infected with fowl cholera, failed to change the pathogenic properties of the virus.

D. Bluecomb in Turkeys

Contract investigations at the University of Minnesota show that bluecomb disease continues as one of the serious disease problems of turkeys of all ages. The enterovirus that has been consistently isolated from the intestinal tract of poults involved in bluecomb disease did not reproduce the bluecomb syndrome when given to 1-day and week old turkey poults.

Poults challenged three days after such an oral feeding of the virus did not have any immunity when exposed to intestinal material.

Tissue culture studies with chicken and turkey primary cell cultures indicated the enterovirus did not produce cytopathogenic effects in these cultures.

Immunity studies are continuing to determine what relationship the enterovirus has with the bluecomb disease and if it will produce any protection against the disease. (Minnesota) (ADP a5-19(C))

E. Avian Leukosis

Studies on this problem under cooperative agreement with the Regional

Poultry Research Laboratory, USDA, East Lansing, Michigan, will be reported by the Poultry Research Branch of the Animal Husbandry Research Division.

Basic studies on this problem conducted at Cornell University under cooperative agreement, were directed to attempts to substitute cytopathogenic viruses for Rous Sarcoma virus in the resistance inducing factor (RIF) test. This work is best presented as follows:

Rubin has shown that chick embryo fibroblast cultures infected with Resistance Inducing Factor (RIF-virus) did not support the growth of Rous sarcoma virus (RSV). Experiments were designed to demonstrate whether inhibition would also occur when RIF-infected cells were challenged with other cytopathogenic viruses.

Fibroblast cultures were prepared from chick embryos known to be free of RIF-virus. The cells were divided into two lots; one maintained serially as a control line, the other inoculated with RIF-virus and carried serially as an infected line. When preliminary trials indicated that the RIF-infected cell line had developed resistance to RSV, parallel titrations with RSV, fourteen avian entero-viruses, Newcastle disease virus, infectious laryngotracheitis virus, and canine distemper virus were done in both RIF-free and RIF-infected cultures. Two trials using a microscopic-plaque technique and one trial using gross-plaque techniques were done. Results indicated that RIF-infected fibroblasts, while resistant to RSV proliferation supported the growth of the other viruses and underwent the cytopathic changes produced by them. (Cornell) (ADP a5-22)

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PARASITES AND PARASITIC DISEASES OF POULTRY
Animal Disease and Parasite Research Division, ARS

Problem. Parasites and parasitic diseases probably cost the poultry industry many millions of dollars annually by causing intestinal disturbances, emaciation, retarded growth, reduced egg production, and deaths. Parasites are ubiquitous, many times insidious, and often overlooked until birds are damaged irreparably. Early diagnosis is difficult, and reliable treatments for many devastating parasitoses are not available. Moreover, some management practices, intended to avoid spread of parasites and to control them, have been found ineffectual as is shown by the increasing importance of certain parasites in broiler production. The problem is to develop, through a planned, balanced program of basic and applied research, methods for preventing, controlling or eradicating parasitic diseases, thus affording economical production of healthy poultry and sound products in supplies adequate to meet the needs of an expanding population.

USDA PROGRAM

The Department has a continuous long-term program involving parasitologists, biologists, and chemists, engaged in both basic studies and the application of known principles to the solution of the problem of parasites and parasitic diseases of poultry.

The Federal scientific effort devoted to research in this area totals 5.5 professional man-years. This effort is applied as follows:

Bionomics of Intestinal Protozoan Parasites 0.5 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

Immunology of Protozoan Parasitic Diseases 1.5 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

Control of Coccidiosis 2.0 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

Biology of Nematode Parasites 1.5 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Control of Coccidiosis.

Studies at the Beltsville Parasitological Laboratory (BPL) have shown that Eimeria acervulina oocysts in potassium dichromate produced 58% excystation after storage for 318 days in a refrigerator in which the temperature dropped below freezing for an undetermined interval. Oocysts from the same culture,

however, did not produce infection in 4-week-old chickens. The sporozoites that excysted in vitro were in poor condition and, contrary to the usual case, did not survive long. These findings indicate that sporozoites can excyst and be non-infective.

Earlier studies showed that 3-day-old chicks produced 13 times more oocysts than did 1-day-old birds when both age groups were given similar dosages of sporulated oocysts. Investigations of this marked difference in oocyst yield revealed that the following factors may be involved: (1) amount of development of the gizzard mucosa and musculature; (2) intestinal concentrations of trypsin and chymotrypsin--pancreatic enzymes involved in the excystation process--in the vicinity of the sporocysts; (3) amount of yolk sac material in the intestine, and (4) amount of development of the intestinal villi.

In continuing studies, chicks were raised to 7 to 8 days of age with bacterial populations in their intestines sufficiently reduced so that cultures of duodenal tissue could be prepared using only minimal amounts of antibiotics. During the year, 24 chicks were hatched and raised by a very simple and inexpensive method. There was no contamination of duodenal tissue cultures.

A Trithiadol-fast strain of Eimeria tenella was developed experimentally at BPL. It proved resistant to the field level of Trithiadol recommended by the manufacturers and, in addition, exhibited a degree of tolerance to nitrofurazone, Unistat, and Zoalene.

Nihydrazone, a recently introduced nitrofurane compound, was tested for effectiveness against cecal coccidiosis (Eimeria tenella). It proved effective in preventing mortality and reduced the severity of cecal lesions to a significant degree; growth of infected nihydrazone-medicated birds, however, was poor. A similar level of medication did not adversely affect the growth of uninfected birds.

Various combinations of chlortetracycline, sulfaquinoxaline, and terephthalic acid were included in the diet of birds infected with cecal coccidiosis. Low-level chlortetracycline (0.0055%) was potentiated to some extent by 0.5% terephthalic acid, but not sufficiently to be commercially practical. Effectiveness of the prophylactic level of sulfaquinoxaline (0.0125%) was increased by the addition of chlortetracycline, as was already known.

Mutual cross-resistance was noted between a nitrofurazone-resistant and a zoalene-resistant strain of Eimeria tenella. At the same time, the nitrofurazone-resistant strain did not prove to be resistant to glycarbylamide or Trithiadol, even though strains resistant to these compounds were also cross-resistant to nitrofurazone. (ADP b4-9)

B. Biology of Nematode Parasites.

Research at BPL has shown that the processes by which the infective agents (sporozoites) are released or "excyst" from oocysts of chicken and turkey

coccidia are similar. Two species, Eimeria acervulina of chickens and E. meleagrimitis of turkeys, which live in the upper small intestine, excyst rapidly in the region that they infect, while two species, E. tenella of chickens, and E. gallopavonis of turkeys, require more time for excystation and excyst in the middle and lower intestinal tract close to the tissues that they infect. (ADP b4-11)

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POULTRY INSECTS
Entomology Research Division, ARS

Problem. Numerous species of insects, mites, and ticks are common pests of poultry throughout the country and if not controlled can make poultry raising unprofitable. They cause poultry to look unsightly, reduce weight gains and egg production, and mar the skin, which results in downgrading of quality and lower market prices. Pests such as black flies and mosquitoes transmit leucocytozoon and fowl pox diseases which exact a heavy toll in death and unthrifty poultry each year. House flies spread parasites and enteric diseases which may decimate flocks. Safer more effective non-residue-forming insecticides are needed to combat these poultry pests and vectors of diseases of poultry. Better materials are needed for direct application to poultry or in poultry houses to control lice, mites, and ticks and for use as larvicides or fly baits to control flies. Materials are especially needed which, when given in feed or water would act systemically to control external pests and render droppings toxic to fly larvae. Exploratory studies are needed to investigate possibilities of developing attractants, chemosterilants, antimetabolites, or other new methods of combatting poultry pests. Biological and sanitation methods of control offer excellent possibilities for control and need to be emphasized. There is a special need to investigate the roles of insects, ticks, and mites in the transmission of poultry diseases.

USDA PROGRAM

A continuing study is underway involving basic and applied research on insects, mites, and ticks that affect the health and productivity of poultry. Studies are designed to determine breeding habits and reproductive capacities of various poultry pests and to gain further knowledge on the nature of resistance of these pests to certain insecticides. Work at present is devoted mostly to lice and the northern fowl mite, and to the house fly, which breeds abundantly in poultry droppings. A newly expanded program aims to find new ways to control pests of poultry with special emphasis on chemosterilants, antimetabolites, attractants, and noninsecticidal materials and methods. Current studies in this field are largely limited to house flies. They include investigations of physical and mechanical methods for controlling house flies being conducted in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions.

Research is concerned with the development of more effective insecticides for the control of poultry pests. New chemicals are screened for contact and residual toxicity to lice and mites attacking poultry and to house flies, and promising ones are tested for effectiveness under practical field conditions. New methods of utilizing insecticides more efficiently and safely are being investigated, with special attention to finding materials that, when given orally in water or feed, will act systemically to kill lice and

mites on the poultry, and render the droppings toxic to fly larvae. Efforts are also being given to methods of sanitation and management to control fly breeding in accumulations of manure in poultry houses. Studies are conducted to determine the occurrences of residues in tissues of poultry treated with insecticides. Work is done in cooperation with poultry raisers at Orlando, Fla., Stoneville, Miss., Corvallis, Oreg., and Kerrville, Tex. Additional research is conducted at Fresno, Calif., and Beltsville, Md.

The Federal scientific effort devoted to research in this area totals 2.2 professional man-years. Of this number, 0.4 is devoted to basic biology, physiology, and nutrition; 0.9 to insecticidal and sanitation control; 0.2 to insecticide residue determination; 0.6 to insect sterility, attractants and other new approaches to control; and 0.1 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology and Physiology

1. House Flies. At Orlando, Fla., research on control or eradication through the use of sterilization by radiation or chemicals has shown that considerable gaps exist in knowledge of the biology and mating behavior of house flies. Both males and females must undergo a sexual maturation time of at least 16 hours with males and a minimum of 24 hours with females. Once the mating drive has started, males will attempt to "strike" or mate with both males and females and certain inanimate objects, although they "strike" more readily and frequently with females. This fact along with experiments in a large cage-type chemotactometer suggested the presence of some type of a female sex attractant of a low order. Imperfect sex recognition in the male combined with a low order sex attractant in the female would account for the fact that males attempt to mate with either sex and result in the higher ratio of male-to-female "strikes." Males or females which had their wings removed were able to mate with individuals of the opposite sex with wings. Amputation of more than one pair of legs from the male prevented mating, whereas amputation of only one pair of legs impeded but did not prevent mating.

Tests were run to determine the actual time house flies remain in copula after initial seizure. Of 61 mating pairs that were trapped and observed, the shortest mating period was 44 minutes and the longest, 96 minutes. The average was 60 minutes. After mating periods of only 1 and 2 minutes, no sperm were found in females, but after 3 to 5 minutes some spermathecae contained a few sperm and some were completely filled. For periods of 10 to 76 minutes spermathecae were filled to capacity with sperm with only one exception.

Observations on the natural sterility of 86 female house flies reared in the laboratory gave an average of 94.4 eggs per female of which 89% hatched. The number of eggs laid varied from 12 to 186 per female.

Investigations to determine how soon male and female house flies fed after emergence showed that some flies fed within an hour after emergence, others did not feed until later, and some did not feed until they were 16 to 18 hours old.

At Corvallis, Oreg., studies were continued on the physiology of resistant and susceptible house flies. Experiments have shown that Isolan-resistant house flies have decreased ali-esterase activity and increased Isolan-detoxifying enzyme. Techniques using high-speed centrifugation have been developed which concentrate enzymes important in metabolizing or conferring resistance to organophosphorus compounds. Experiments with malathion-resistant house flies indicate that the nature of the alkyl groups attached directly to the phosphorus atom is the major factor in resistance. Thus, the primary cause of resistance is probably associated with the rate of recovery of the phosphorylated detoxifying enzyme after poisoning, rather than to an increased ability to cleave the toxic molecule per se.

In Oregon extensive studies were conducted on the biology, nutrition, and colonization of the little house fly (Fannia canicularis). After much trial and error a satisfactory rearing medium was developed which consisted of alfalfa meal, yeast extract solution and wood shavings. Adult flies are held in standard cages. Wrinkled balls of black muslin impregnated with alfalfa and yeast extracts are provided as oviposition sites. Forty-eight percent of the females and 25% of the males survived for 22 days in cages kept at 70-80°F. At 90°F. no males and only 8% of the females survived for 22 days. Egg deposition was about 5 times as great at 80°F. as at 70° or 90°F. Females began ovipositing in 5-6 days at 90°F., 8-9 days at 80°F. and 10-11 days at 70°F. The eggs dessicate rapidly and must be kept constantly on a moist surface to insure a high percentage of hatch.

2. Mosquitoes. At Corvallis, Oreg., and Fresno, Calif., studies were continued on the biology and ecology of important mosquito species. In laboratory tests the majority of Culex tarsalis females preferred to feed at the higher of two feeding locations and preferred mice rather than chickens for their source of blood.

A study was conducted on the daily activity of several species of mosquitoes --Anopheles freeborni, Culex peus, Culiseta inornata, Culex incidens, and Culex tarsalis. All species behaved similarly. Both males and females began to move out of daytime resting shelters a few minutes before or after sunset. Only a few males and females (0.3 to 2.8%) remained in the shelters during the night. Adults did not begin to return to the shelters until sunrise or a few minutes later, and all did not return until sometime after 8:00 a.m. Exodus from and return to shelters appeared to be regulated by light intensity, but some other factors such as preconditioning to light cycles, temperature, and humidity may have had some effect since artificial lights did not prevent mosquitoes from leaving shelters eventually, but did change their time and rate of leaving. Use of special crosses of resistant

and susceptible strains of Culex tarsalis showed that some of the females mate more than one time and utilize sperm from more than one mating.

Taxonomic studies in California have defined suitable characters for separating dark-winged forms of Aedes dorsalis from A. melanimon and have shown that these two forms coexist in only one area (Solano County). Surveys at Borrego Springs (San Diego County) were made to find isolated populations of mosquitoes for future studies on control through sterilization.

Surveys were continued on biting arthropods of the Humboldt River Basin in Nevada. During April, May, and June, water was plentiful and high populations of Aedes melanimon, A. dorsalis, A. vexans, Culex tarsalis, and Culiseta inornata were found. Mosquito larvae were infected with a microsporidian, Thelohania sp. and a bacterium, both of which are under study as biological control agents. In late July, no floodwater Aedes breeding was observed, but moderate breeding of Culex tarsalis and Culiseta inornata was observed. Studies of mosquito larval populations in typical breeding areas in dairy drains and culverts in California during April indicated the presence of Culiseta inornata, Culiseta incidens, Culex tarsalis, Culex peus, Culex apicalis, and Anopheles franciscanus, but no breeding of Culex quinquefasciatus was found.

Using C-14 labeled TDE, slight but consistent differences in its rate of degradation have been noted in Oregon in susceptible and resistant strains of Culex tarsalis indicating that the main source of resistance to this chemical is increased degradation of TDE to FW-152 and water soluble metabolites through an oxidative rather than a dehydrochlorination mechanism. Further tests with DDT and TDE have shown that analogs of DDT, which block metabolism via the oxidative pathway, overcome resistance to DDT and tend to confirm the hypothesis that resistance to DDT and TDE in tarsalis is a more rapid oxidative metabolism of the insecticide.

B. Insecticidal and Sanitation Control

1. House Fly. Research was continued at Orlando, Fla., to develop more effective insecticides and other methods and materials for the control of house flies. Twenty-three new compounds were tested as space sprays in a wind tunnel against the regular susceptible colony and the Cradson (multiresistant) colony. Fourteen of the compounds were more effective against both the susceptible and resistant colonies than the standard, malathion. New insecticides were also evaluated as residual treatments against female house flies from the regular or Cradson colonies. The criterion of effectiveness was the number of weeks of aging during which the residues remained effective in killing house fly females. Against susceptible house flies Hercules AC-5727 alone and Bayer 39007 alone gave kills of 90% for one week, but in combination with Monsanto CP-16226, their effective periods were extended to 8 weeks and 12 weeks, respectively. The

effectiveness of Hercules 7522H was also extended from 1 to 12 weeks with the addition of Monsanto CP-16226. Against flies of the Cradson colony all of these formulations failed before the fourth week. Against the regular colony, Bayer 29952 and Bayer 30237 were effective for 64 and 56 weeks. Stauffer N-2230 and Stauffer N-2404 were 100% effective throughout 48 weeks of aging against the susceptible colony, but they were ineffective against the Cradson colony. General Chemical GC-3583 was still 100% effective after 96 weeks against the regular colony and Monsanto CP-40294 was effective for 24 weeks against the Cradson colony. Against house flies from the susceptible colony, General Chemical GC-4072 was 100% effective for 96 weeks as an acetone solution and Stauffer N-2310, Bayer 39197 and Monsanto CP-40273 for 48+ weeks. As wettable powders, DDT was more than 90% effective for 48 weeks, Bayer 25141 for 48 weeks, Bayer 34098 for 40 weeks, Hooker HRS-1422 for 32 weeks, and Bayer 32651 for 28 weeks.

Residual tests (deposits of 100 mg./sq. ft.) were conducted with emulsions of diazinon, Baytex, and dimethoate against house flies in Florida dairy barns. The diazinon treatment failed to give satisfactory control as early as the first day after treatment. Baytex gave 97% control for 5 days and from 79% to 88% control through 14 days. Dimethoate gave controls ranging from 80% to 96% for 6 weeks, when the test was discontinued.

At Corvallis, Oreg., extensive studies were continued on the development of synergists that have overcome resistance to organophosphorus insecticides in both house flies and mosquitoes. Of some new types of compounds screened, results indicate that diisopropyl or dibutyl analogs would be most satisfactory. Selection of house flies with combinations of malathion and synergists are being carried out to determine if resistance to the combinations can be developed.

2. Mosquitoes. Studies were continued at Orlando, Fla., to find new and effective insecticides for the control of mosquitoes. In screening tests with Anopheles quadrimaculatus larvae, 28 of 81 compounds tested were rated Class IV in effectiveness. Four of these compounds--American Cyanamid CL-18133, Stauffer B-10046, Stauffer 8-10094, and Bayer 47940--were highly effective, killing 100% of the larvae at concentrations of 0.05 p.p.m. to 0.01 p.p.m. One hundred and nine plant extracts were also screened for toxicity, but none of these were toxic at low concentrations. Of 83 compounds tested against female Aedes taeniorhynchus in wind tunnel tests, 7 were as effective as the standard, malathion. Dimethrin in granular formulations was effective in laboratory and field tests as a larvicide against Anopheles quadrimaculatus, Aedes aegypti, Aedes taeniorhynchus and Culex quinquefasciatus mosquitoes. A mixture of DDT and anti-resistant compound was no more effective than DDT alone against C. quinquefasciatus larvae.

In Oregon, 46 compounds were tested for systemic action by giving them orally to mice and allowing mosquitoes to feed on the mice. At a dosage of 100 mg./kg. two compounds--Bayer 29493 and Shell SD 8436--killed all mosquitoes for 6 hours after the mice had been treated.

3. Lice and Mites. Nineteen chemicals were tested in Texas for control of poultry lice on chickens. All but two chemicals controlled all species of lice for at least 3 weeks at a level of 0.1% in sprays; 15 chemicals were fully effective for 3 weeks at 0.05%, and 3 chemicals were effective at 0.025%. All treatments were applied as sprays directly to the individual birds.

White leghorn hens having body lice (Eomenacanthus stramineus) and wing lice (Lipeurus caponis) were sprayed or dipped in Dowco-175 or Ciodrin. Each bird was treated individually. In the Dowco-175 tests, both full dips and 40 ml./bird sprays killed all lice within 3 days at concentrations of 0.05% to 1.0%. The Ciodrin tests were conducted to compare the effectiveness of 0.05% and 0.1% in sprays, 0.05% in full dips, and 0.05% in dips in which only the tail of the bird was immersed. All Ciodrin treatments eliminated lice prior to 10 days post-treatment. In all these tests, after the initial 10 days of isolation, the treated birds were placed together in a henhouse with 4 untreated birds in an attempt to either reinfest the treated birds, or decrease the population of lice on the untreated birds. No change occurred on either throughout the 16-day observation period.

A flock of 800 white leghorn laying hens was sprayed with 0.25% Ciodrin for the control of the chicken body louse (Eomenacanthus stramineus). Spraying was accomplished by dividing the flock into three groups and spraying each group as a unit. Ten gallons, or about 47 ml./bird, was used for the flock and an attempt was made to treat both the tops and bottoms of the birds; however, coverage was considered only fair. Forty birds, chosen at random, were examined before and at intervals after treatment. Prior to spraying, all were heavily infested. Two days after spraying, 11 of 40 birds examined had lice, and only 2 birds had counts above 10 lice per bird. From 2 weeks to 4 weeks after treatment, from 5 to 13 of the 40-bird samples had lice and all counts were below 10 lice per bird. At 5 weeks after treatment, 11 of the 40 birds examined had lice and the population of lice per bird was increasing; one bird had 50 lice.

Preliminary surveys with northern fowl mites, taken from live birds at Hansen's Leghorn Ranch in Corvallis, Oreg., indicated that approximately the same order of resistance to malathion existed as when the population at this ranch was first assayed in 1958. Some of the mites were used to infest birds at the laboratory. Mites from this laboratory colony were used in further tests, in which malathion alone was tested in comparison with malathion combined with each of three synergists in a 1:1 ratio. Approximate LD-50 and LD-90 values for the malathion alone were 0.0072% and 0.017%. For malathion plus ENT-25812, the values were 0.00185% and 0.0029%, respectively; for malathion plus ENT-25989, the values were 0.00066% and 0.0012%, respectively; for malathion plus ENT-25988, the values were 0.00044% and 0.0005%. The malathion-ENT-25812 combination was 4 and 6 times more toxic than the malathion alone; the combination with ENT-25989 was 11 and 14 times more toxic than malathion alone; the combination with ENT-25988 was 16 and 34 times more toxic than the malathion alone. As these synergists are believed to be specific in restoring susceptibility to malathion in some malathion-resistant insects (flies

and mosquitoes), the studies suggest some resistance is developing to malathion in a population of the northern fowl mite.

Tests were conducted in Mississippi with Dowco-175 and Ciodrin for control of the northern fowl mite (Ornithonyssus sylviarum). Both chemicals were used as a spray (40 ml./bird) at concentrations of 0.05%, 0.1% and 0.25% and as a dip at these concentrations and at 0.025%. When used as a dip, Dowco-175 was effective at all concentrations except the lowest (0.025%), which failed after 20 days. As a spray, Dowco-175 at 0.05% was ineffective. Mites were present 28 days after treatment at 0.1%, but not at 0.25%. As a 0.25% dip, Ciodrin was completely effective after 28 days. However, as a dip at other concentrations, this material failed between 20 and 23 days after treatment. The lowest spray concentration, 0.05%, was ineffective; the treatment at 0.1% failed after 20 days and the one at 0.25% failed after 23 days.

4. Fleas. In Texas, white leghorn hens having sticktight fleas (Echidnophaga gallinacea) were sprayed or dipped in Dowco-175 or Ciodrin. Each bird was treated individually. In the Dowco-175 tests, fleas were eliminated at 0.1% and above, but not at 0.05%. In the Ciodrin tests, fleas were eliminated by both sprays and full dips. Tail dipping reduced the flea population by about 65% at 10 days, but the number of fleas was increasing again by the 20th day. When sprays were used, about 40 ml. was applied per bird. A flock of 26 white leghorn hens, heavily infested with sticktight fleas was dipped in 0.25% suspension (prepared from a wettable powder) of ENT-17470. The hen-house was sprayed with 1/2 gallon of the suspension and the nest boxes and nest material replaced. No control of the fleas was evident 4 days after dipping the birds and the entire flock was redipped in 0.25% ENT-17470 in emulsion form, again with no control. One week later, the flock was dipped from head to the base of the wings in 0.25% emulsion of ENT-25780. An estimated 95% mortality of the fleas was observed 2 and 5 days after this dipping, but by the 12th day, the flea population had increased to 10-25 per bird. The birds were redipped in 0.25% ENT-25780, 20 days after the first treatment with this material. Seven days after this second treatment, the birds were clean of fleas, but at 14 days, 1 flea was found and at 21 days, 6 fleas were found on the flock.

C. Insecticide Residue Determinations

1. Toxicity Studies. Initial tests with Dowco-175 in Texas to determine maximum levels chickens could tolerate were conducted with this chemical in sprays (40 ml./bird) and dips, at concentrations ranging from 0.05% to 1.0%. Birds dipped in 1.0% showed evidence of toxicity but recovered following atropine therapy supplied by a cooperating Animal Disease and Parasite Research Division veterinarian.

D. Insect Sterility, Attractants, and Other New Approaches to Control

1. House Flies. Research on the development of sterilization for the control or eradication of house flies has been continued in Florida and Oregon. In

Florida, investigations involved the screening of candidate chemosterilants, secondary laboratory tests with promising compounds, experiments related to actual field conditions, experiments with natural populations, and fundamental studies on effects of chemosterilants on house fly physiology and cytology. Eight hundred and eighty six new chemicals were screened for sterility activity. Of these some produced toxic effects; however, 90 caused complete or partial sterility in the treated house flies. Many promising compounds have been further evaluated for their effects on individual sexes, their maximum tolerated as well as minimum effective dosage, and other methods of administering the compounds to house flies. Seven compounds were highly effective in sterilizing both sexes of house flies, but two of these were also toxic at the dosages tested. Metepa and tepa as residual deposits on glass sterilized house flies at dosages from 25 to 250 mg. per sq. ft., but 5-fluoroorotic acid was ineffective as a residual deposit at similar dosages. Apholate in the adult food sterilized house flies regardless of their age and the flies did not regain fertility. Motile sperm were present in the testes of chemosterilized males and transferred during copulation to the spermathecae of females throughout the life span of the male.

Tests were initiated to determine whether a dosage of chemosterilant too low to prevent hatching or adult emergence might by the accumulation of small genetic injuries eventually reduce or eliminate reproduction. With apholate, one colony showed reduction of oviposition in the 4th, 5th, 6th, and 7th generations and no individuals reached the pupal stage in the 7th generation. With metepa, the 5th through 9th generation of another colony showed reduced oviposition and the 10th generation failed to oviposit.

Preliminary tests with apholate, tepa, and metepa, and house flies indicated that the probit of the percent sterility with house flies can be related to the log of the concentration.

Metepa and apholate shortened the life span of adult house flies considerably, but 90% or more of the male population survived the first 10 days, or that period of time in which mating activity is the greatest. Survival during the first 10 days was essentially the same in treated and non-treated house flies. In other experiments house fly pupae were dipped in solutions of tepa, apholate, or metepa. This treatment was toxic to most individuals, but a high degree of sterility occurred in individuals surviving the treatment. Tests have been conducted with various formulations and types of baits for administering chemosterilants to house flies. Effective formulations of both dry baits and paint-on liquid baits have been developed.

Studies conducted in Oregon with an olfactometer and with simulated treated fly models (pseudo flies) demonstrated the presence in female house flies of a volatile chemical or chemicals which can influence the behavior of male flies. The behavior modification elicited was in the nature of attraction to a source of the pheromone, or an excitation of mating behavior patterns. The

material, which is benzene soluble and relatively stable, was shown to be sex related, and appeared to be specific to the house fly since extracts of neither the face fly or stable fly affected the behavior of male house flies.

In Oregon tests were conducted to determine sterilizing effects of tepa and metepa on the little house fly (Fannia canicularis). All flies feeding on bait containing 0.1% tepa for 4 days and 0.5% tepa for 2 days succumbed in 3 and 5 days, respectively, and none oviposited before death. Flies feeding on 0.05% tepa for 3 days survived normally but did not oviposit. Metepa at 0.5% was highly toxic to flies. Those feeding on baits containing 0.05 and 0.1% metepa survived and laid a few eggs but none hatched. Longevity of flies exposed for 2 hours on 100 mg. per sq. ft. residues of tepa was greatly reduced and all flies were fully sterilized. Flies exposed on residues of 1 and 10 mg./sq. ft. laid a few eggs but none hatched. These tests indicate that the little house fly is much more easily sterilized than the house fly. Over 50 inorganic and organic materials were tested as attractants for the little house fly. None showed significant attractancy.

In cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions, studies were continued in new facilities at Beltsville, Md., to develop physical and mechanical methods of controlling house flies and other flies. Colonies of flies were established for the conducting of laboratory and outdoor cage studies. Studies to date have been concerned primarily with the attractiveness of various flies to different kinds and intensities of light. Black light ultraviolet radiation was attractive to both house flies and face flies during twilight periods. The use of fluorescent panels behind light sources appeared to increase the attractiveness.

2. Mosquitoes. In Oregon tepa and ENT-50450 were tested as sterilants against *Culex tarsalis* adults by spraying in wind tunnel tests and against larvae by exposure in water. Tepa sterilized males and females at a spray concentration of 6%; ENT-50450 sterilized only males at this concentration. Lower concentrations of either compound were not effective. Against larvae, both compounds were toxic at higher test concentrations and ineffective and partial toxicants at lower concentrations.

In Oregon studies have shown that grass infusion and log pond waters are attractive to ovipositing female Culex pipiens quinquefasciatus. Studies have shown that distilled water treated with methane or furfural are more attractive to ovipositing females than distilled water, but less attractive than log pond water.

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EQUIPMENT AND BUILDINGS USED IN POULTRY PRODUCTION
Agricultural Research Engineering Division, ARS

Problem. The American farmer has about \$14 billion invested in service buildings and related structural equipment, over half of it for livestock facilities. Maintenance and new construction amount to another \$1.2 billion annually, again mostly for livestock facilities.

Economic conditions are forcing changes in the pattern of livestock production. Producers are trending toward fewer, larger and more specialized enterprises and toward "confinement" types of facilities in their effort to reduce production costs and improve product quality. These trends are demanding more basic knowledge on the effects of environment on the health, growth, production and fertility of livestock; on structures and related equipment for maintaining optimum environments; and on methods, structures and equipment for more efficient handling and feeding. The continuing threat of nuclear warfare demands consideration of types of buildings that could provide protection from fallout for livestock and their feeds, and provide facilities for operation during periods of emergency.

Much more needs to be learned in the laboratory on the relationships between livestock environment and disease transmission, feed conversion rates, and growth and production in order to determine optimum environments. Structures and equipment for economically providing these optimum environments under practical conditions need to be developed and field tested. Closely associated with the environment are flies and other insects, as well as parasites and diseases, that sap the vitality of animals and reduce their productivity. Pesticide residues in animal products are causing much concern. Information is needed on means for keeping these residues from adversely affecting the animals or their products.

Labor also is an important element in overall production costs, and if only family labor is available, the labor requirement limits the size of enterprise. How to adapt existing buildings and other facilities for more efficient production, as herds and flocks are increased in size, or as farms are consolidated, is a major problem area. Cost of replacement or major improvement of existing buildings that are not suited to modern production methods are serious obstacles. Principles, examples and techniques for planning more efficient operations are needed both by farmers doing their own engineering and by those on whom farmers depend for advice.

Today's technology in farming requires accurate instruments for measuring or monitoring processes such as grain and forage drying and plant and animal environment. Some problems require completely new kinds of instruments. Studies are necessary to determine the accuracy and practicability of instruments for many kinds of agricultural instruments.

USDA PROGRAM

Research pertaining to livestock engineering is a continuing program involving engineers and architects conducting basic laboratory investigations, application of laboratory results to a production basis, and development of typical plans for livestock structures. The work is in cooperation with the AH, ADP, and ENT Divisions of ARS, USDA, and State Agricultural Experiment Stations, and contributes to Cooperative Regional Projects NC-23, "Farm Structures to Meet Environmental Requirements of Dairy Cattle, Swine, and Poultry," and NE-8, "Essentials of Poultry Housing for the Northeast." Plan development work is cooperative with all the State Agricultural Experiment Stations and Extension Services.

Poultry house environmental design criteria are investigated in controlled-temperature laboratory studies at Beltsville, Md., in cooperation with AH, ARS. Field studies on relation of housing structures to poultry disease are conducted in Mississippi in cooperation with the State Experiment Station and AH, ARS. Environmental influences on health and housing are to be investigated in new laboratories at Athens, Ga., and State College, Miss., in cooperation with AH and ADP, ARS, and the respective State Agricultural Experiment Stations. At St. Paul, Minn., a study of the role of environment in the prevention and control of chronic respiratory disease in turkeys is underway in cooperation with the Minnesota Station. Typical plans for poultry structures are developed at Beltsville.

Federal research in the area of livestock engineering totals 9.1 professional man-years. Of this number 2.2 is devoted to dairy; 0.3 to beef; 1.3 to swine; 3.2 to poultry; 0.1 to shades and shelters; 0.2 to sky radiosity studies; 1.0 to reducing pesticide residues in animal products; and 0.8 to program leadership.

Federal research in the area of electric equipment for farm labor reduction involves 5.0 professional man-years of which 2.5 are devoted to livestock and poultry.

The Federal scientific effort devoted to research in the area of electric and solar equipment for environmental control totals 5.9 professional man-years, of which 2.0 are devoted to poultry.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Poultry Engineering

1. Calorimeter studies. At Beltsville, Md., in cooperation with AH, the 300- to 380-day old second-generation inbred strain of heat-resistant Arizona SCWL laying hens was checked for heat dissipation characteristics at 65°, 85°, and 95° F. (These birds were developed at the USDA Southwest Poultry Experiment Station, Glendale, Arizona). Comparison between Arizona

and previously tested Beltsville strains of SCWL showed some strain differences. Mainly these differences were within the 95° F. tests where the Arizona strain ate 26% more feed and had a 43% greater rate of heat dissipation. However, water consumption was about the same for each strain, as was the ratio of latent to total heat dissipation. These results suggest that the Arizona birds may attain high egg production rates in hot weather through more efficient utilization of feed.

Also in the calorimeter at Beltsville, the following schedule was adopted in a long-term study of the effects of temperature on growth and heat and moisture production of Athens Randombred broilers:

Trial	Temperature Levels of Calorimeter	
	A	B
1	5 C	30
2	25	10
3	30	5
4	10	25
5	20	15
6	15	20

In this schedule, the calorimeters and the temperature levels were randomized, with humidity set at about 75% RH. Trial I was completed March 15, 1963.

2. Southeast poultry disease laboratory. Considerable engineering time was spent in design of equipment and facilities for the new poultry disease laboratory in Athens; this facility (still not completed) will be used in cooperation with ADP, AH, and the Georgia Agricultural Experiment Station. In addition, an environmental cabinet was designed and initial performance tests were started. This will serve as a prototype for 8 to 12 such cabinets to be used in the laboratory. Some parameters included in the design were:

- (1) Floor space for 30 to 40 broilers.
- (2) Air temperature programming, 20 to 110° F. range.
- (3) Relative humidity programming, 20 to 90% range.
- (4) Sidewall temperature programming, 20 to 110° F. range.
- (5) Roof or cover temperature programming, 20 to 130° F. range.
- (6) Floor temperature programming, 30 to 100° F. range.
- (7) Adjustable ventilation rate 0 to 10 cfm per bird.
- (8) Adjustable air flow in cabinet, 0 to 20 cfm per bird.
- (9) Air pollution and control.

3. Field observations on relation of housing to disease in South Central States. At State College, Miss., in cooperation with AH and the Mississippi Station, feed conversion, condemnation, and growth rate of broilers in insulated houses were compared with growth in comparable broiler houses that were not insulated. Results show that other construction and management factors have to be controlled to make insulation an effective means of broiler house environment control. If brooders are not properly regulated, if ridge vents are left open, or if side curtains are not properly adjusted or are in poor condition, added insulation has little affect on operating conditions and consequently upon feed conversion, condemnation or growth rate.

A comparison of broiler houses with the length oriented in an east-west direction was made with those with the length in a north-south direction. The four broods (88,000 birds) studied showed that the broilers grown in east-west orientated houses had less condemnation and as good or better growth rate than those grown in the north-south oriented houses.

Preliminary observations of brooding systems showed that uniform and/or adequate temperatures are not being maintained.

4. Influence of turkey housing environment on disease. At St. Paul, Minn., four tests have been completed comparing infected turkeys grown in environmental conditions differing mainly in ambient temperature values by 15° F. to 20° F. The infectious agent has been the S₆ strain of mycoplasma gallisepticum. Upon completion of each test the turkeys have been New York dressed in a processing plant and then inspected in one of the University laboratories. Three areas of infection were scored numerically from 0 to 3 with the severest lesions receiving a score of 3. A bird with a score of 2 or 3 in at least two areas was classed as condemned.

The data from the first 2 experiments plotted as percent condemnation against average pen temperature indicates a reduction in condemnations with increasing pen temperatures up to 70° F. In the third test the pen temperatures were 70° F. and 79° F. In this test the condemnations were 10% and 28%, respectively. It was theorized that the higher temperature was producing a heat stress. The results of a fourth test, at 40° and 60° F., did not fit into the graph of the previous tests. A plan is underway to eliminate this particular disease from the turkey hatching egg flocks in the State.

The studies bring to light the complex nature of studies involving disease and environment. One of the greatest problems is the loss of wingbands during the plucking operation. Large differences were obtained between replicates with no leads as to the reasons.

5. Plan development. At Beltsville, Md., the design for a laying house containing colony cages was completed for the Northeastern Region and was included in the Cooperative Farm Building Plan Exchange. The ventilation system uses the solar heat gain of the roof for tempering ventilation air. The plan incorporates the results of California research on cage fabrication and Michigan research on manure flushing. It also illustrates use of two-level illumination to conserve power, and presents the concept of sizing summer ventilation for maximum evaporative temperature depression.

B. Poultry Equipment

Also in Illinois an auger feed injector has been placed on field test. It has a 2 1/2-inch o.d. helicoid with a 7/8-inch pitch to force the ground feed into the conveying line. The injector has performed very satisfactorily in the field test. There have been six farmers who, upon seeing the experimental unit, have constructed an auger feed injector and pneumatic conveyor for themselves.

The tests of the auger feed injector thus far completed show that the 2 1/2-inch diameter auger is the best size for a conveyor intended to convey up to 3,000 pounds per hour when turned at 1600 to 2000 revolutions per minute. A 3-inch auger has successfully handled 5,500 pounds when connected to a 1 1/2-inch conveyor pipe. The last convolution of the auger (discharge end) is subject to rapid wear. It must be hardened to give satisfactory service.

C. Equipment for Poultry Environmental Studies

At Beltsville, in cooperation with the Poultry Research Branch, AH, studies of practical systems of lighting turkey breeding flocks are being completed. These studies show that (1) light intensity, from white incandescent sources, of approximately 1 to 40 foot-candles are satisfactory for stimulating reproduction; (2) abrupt rather than gradual lengthening of photoperiod to stimulate sexual activity is advantageous; (3) a shortened light day of 8 hours or a continuous light intensity during the hours of natural daylight of approximately 0.1 foot-candle of 8 weeks duration, will precondition out-of-season turkey hens for subsequent reproduction; (4) environmental temperature control in winter and spring breeding seasons for Beltsville climate shows no relation between temperature and reproductive performance.

At Beltsville, in cooperation with the Poultry Research Branch, AH, a pilot study was conducted in existing facilities beginning in 1961 to determine the feasibility and problems of maintaining birds on a subcircadian 18-hour cycle. One hundred and sixteen hens were divided equally into a 24-hour cycle and an 18-hour cycle group. There were little or differences in percent hen-day egg production between the two groups. Data on time of oviposition for the 18-hour group indicated that more than half the eggs were laid during the dark period of the cycle with a peak during the early part of the dark cycle. Equipment for determining exact time of lay was experimentally used on cages of 20 birds over a period of 5 months.

In 1962 a larger facility was revised to house 300 birds where temperature is maintained at approximately 62° F. during the light period and approximately 75° F. during the dark period.

Selection for the second year's study was on the basis of response to 18-hour cycle. Control birds are maintained on a 24-hour cycle.

Equipment for automatic recording of time of lay by individual birds is planned and a control facility for continuous maintenance of a 24-hour group is in preparation. Experimental pilot studies of automatic recording of time of lay by individual birds resulted in accuracies of 75 percent. Cages and egg sensing devices are being modified to attain higher accuracy.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Poultry Engineering

Ota, H., and McNally, E. H. 1962. Poultry investigations with the Beltsville Respiration Calorimeters. Presented at ASAE Meeting, Washington, D. C., as Paper No. 62-426.

Junnila, W. A., and Otis, C. K. 1962. Which ventilation system for you? Turkey World, V. 37, No. 9, September.

Teter, N. C., and Ota, H. 1962. Insulating materials and vapor barriers, their value and application. Presented at Broiler Housing Seminar, Georgetown, Delaware.

Ota, H., and McNally, E. H. 1962. Studies on Arizona and Beltsville strains of SCWL. Abstract, presented at NE-8 Committee Meeting, New York City.

Poultry Equipment

Klueter, H. H., Puckett, H. B., Beaty, H. H., and Olver, E. F. 1962. Medium pressure pneumatic conveying. Agricultural Engineering Journal, Vol. 43, No. 10, pp. 572-575.

Puckett, H. B. 1963. Automatic feed grinders. Presented at the New England Farm Electrification Institute, University of Vermont, Burlington, Vermont.

Equipment for Poultry Environmental Studies

Marsden, S. J., Cowen, N. S. and Lucas, L. M. November 1962. Effect of gradual and abrupt lengthening of photoperiod on reproductive response of turkeys. Poultry Science, Vol. XLI, No. 6, pp. 1864-1868.

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II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville, Maryland, and in Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 4.9 man-years is concerned with studies related to poultry and poultry products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to egg products are considered briefly in this report.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutrient Values of Poultry and Poultry Products

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8 "Composition of Foods...Raw, Processed, Prepared" was completed and carried through to the galley proof phase. More kinds of poultry and more detail under each kind, especially for chickens, are included. The data for chickens are subdivided by class (fryers, roaster, etc.), and by raw and cooked. The new table includes about 60 items. Turkey items are subdivided by age and fatness--birds, medium-fat, and fat mature birds--and insofar as possible include raw and cooked forms.

Data in the popular publication, "Nutritive Value of Foods," Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving Nutritive Value of Foods," Home and Garden Bulletin No. 90, is in press.

2. Proteins and amino acids. A manuscript was published describing a method developed for assay of alanine using Leuconostoc citrovorum 8081 and providing data for 48 foods and proteins including eggs, chicken and turkey.

3. Biological value. Lipid biosynthesis is being studied as a possible criterion for assessing the nutritional value of foods. Rats developed acute deficiency symptoms when fed a cholesterol-free diet plus an inhibitor of cholesterol biosynthesis. The content of total sterols in their carcasses and tissues was about the same as for control animals fed a cholesterol-free diet. Analysis of the major sterols by Entomology Research Division showed 75 percent of the total sterols to be desmosterol and less than 20 percent to be cholesterol in the carcasses of the inhibitor-fed rats; in the carcasses of control rats 95 percent of the total sterols was found to be cholesterol. A manuscript presenting these findings has been accepted for publication. In other phases of this research, lipid biosynthesis in relation to age and diet is being investigated.

B. Properties Related to Quality and Consumer Use of Poultry and Poultry Products

1. Heating procedures and eating quality of turkey. Changes in muscle structure, fat and moisture content, tenderness, juiciness, and flavor induced by different heating times, oven temperatures and degrees of doneness used in roasting and braising are being studied for boneless turkey roasts and whole turkeys. Research is in progress on boneless turkey rolls obtained from Iowa and from Virginia, roasted at oven temperatures of 250°, 325°, and 400° F., and to internal temperatures ranging from 161-212° F. Eating quality and heat penetration were determined for 8 Bronze tom turkeys from Virginia, and 10 Beltsville Small White tom turkeys from Maryland, when stuffed and roasted in a 325° F. oven to an endpoint temperature of 195° F. in the breast muscles. Plans are underway to obtain turkeys grown in California for comparison with those grown in Virginia and Maryland. Research under contract with Purdue University has been initiated to study bacteriological and quality characteristics of turkeys stuffed and roasted under different conditions. Results will be used to reevaluate cooking times for large turkeys and the criteria for determination of cooking endpoint.

2. Freezer storage of chicken. Broiler-weight chickens obtained from commercial plants were evaluated for weight loss during cooking and for palatability within 4 days after processing and after 6 months storage at 0° F. Chickens were roasted at an oven temperature of 400° F. to an endpoint temperature of 195° F. in the breast meat. There were no appreciable differences in odor, juiciness, tenderness, or flavor of breast or thigh meat between the unstored or frozen stored chickens. Addition of sodium chloride or sodium polyphosphate to the chill water during processing did not affect the above characteristics. The use of polyphosphate helped slightly in maintaining the flavor of cooked breast meat held in the refrigerator for 48 hours and then reheated. It did not affect the other palatability qualities. Cooking losses were slightly less for chickens treated with polyphosphate than for untreated or sodium chloride treated birds. The work was cooperative with the Agricultural Marketing Service and results will be used in Department publications.

3. Fresh, frozen, and canned poultry products. Preparation time, serving yield, food components, and quality characteristics were determined for home-prepared and purchased canned, chilled, and frozen chicken and turkey products. Commercially prepared foods generally required less time for active preparation and less total preparation time than did the home-prepared counterparts as would be expected. Active preparation time for home-prepared foods ranged from 10 to 54 minutes, depending on the number of ingredients and the complexity of the preparation procedures involved. Less than 10 minutes of active preparation time was needed for preparing four servings of most of the commercial products. Commercially prepared

foods were ready for serving in 2 to 47 minutes total time. Total time for home preparation of commercially prepared foods extended to 242 minutes when it included thawing time, as compared with 250 minutes for completely home-prepared foods that required long cooking.

The lean meat content in frozen poultry dinners or main courses ranged from 19 to 22 percent of the weight of the ready-to-eat food. In chilled and frozen pies, average lean meat content ranged from 12 to 17 percent, and in combination dishes, from 3 to 16 percent. In three brands of frozen chicken dinners, the average meat content ranged from 20 to 22 percent; in two brands of turkey dinners, from 19 to 26 percent; and in three brands of frozen chicken pies, from 12 to 17 percent. Results have been summarized for publication in a Department bulletin on consumer quality characteristics, composition, yield in servings, cost, and preparation time of various market forms of these foods.

4. Freeze-dried poultry products. The general acceptability and eating quality of freeze-dried poultry products in relation to other processed canned or frozen forms of the same food product were evaluated by a laboratory taste panel. Freeze-dried diced chicken generally rated lower than canned chicken on all quality characteristics of flavor, texture, tenderness, juiciness and appearance, and on general acceptability. When the chicken was served in salad or in creamed chicken, general acceptability was better than when it was served plain-cooked. The freeze-dried chicken was described as off-flavored, tough, fibrous, woody, and mealy by the panel.

Freeze-dried chicken stew received palatability scores significantly lower than the canned product, except for appearance and juiciness. Scores for the freeze-dried chicken rice dinner were significantly lower, except for appearance, than for the laboratory-prepared chicken rice dinner.

Scores for freeze-dried chicken rice soup and chicken noodle soup were usually similar to or higher than those for the corresponding canned soup. The flavor of freeze-dried scrambled eggs cooked in sausage drippings was rated fair, but lower than flavor scores for scrambled fresh eggs. The scores for other quality characteristics of freeze-dried scrambled eggs were similar to scores for scrambled fresh eggs. Apparently some quality characteristics of freeze-dried poultry products need improvement before they can compete with frozen or canned poultry products. The results of this research, done in cooperation with the Economic Research Service, have been published in a Marketing Research Report.

C. Nutrient Functions

Lipids. A better understanding of specific relations between diet, health and longevity has resulted from long-term investigations with laboratory animals fed 29 different experimental diets including diets containing

whole egg, egg yolk or egg white. Both excessive food intake and relationship or balance of nutrients in the diet are implicated in the adverse effects that occurred throughout the lifespan of laboratory animals. The studies indicate that genetic strain affects the response to the different diets and thus emphasize the importance of recognizing inherited characteristics in evaluating response to diets. Survival varied even with diets of similar fat and protein content. Differences in serum cholesterol levels of animals showed no relationship to kind or level of fat nor to level of dietary cholesterol.

D. Human Metabolism and Nutrient Requirements

1. Metabolism. Manuscripts are being prepared for publication presenting results obtained in contract research at Los Angeles, California, on the effect of the type of dietary protein on the response to variations in dietary linoleic acid and at Lincoln, Nebraska, and Battle Ground, Indiana, on the effect of the amount of dietary protein on the response to a constant amount of dietary linoleic acid.

2. Requirements for nutrients. A study of nutritional needs of adolescents was conducted under contract at Berrien Springs, Michigan, with a group of adolescent girls, 16 to 19 years of age. The controlled diet used was designed to measure the metabolic response to an ovo-vegetarian type of diet. The major portion of the dietary fat was provided by butter and corn oil. The study will provide data on intake and outgo of nitrogen, fat, and selected minerals, and on blood lipid patterns for use in assessing nutritional requirements of adolescent girls. To obtain data for a more representative group of girls on an ovo-vegetarian type of diet, a replicate study is being planned with another group of 16 to 19 year old girls. Long-range plans include studies with younger adolescents using controlled diets with different combinations of food and different levels of nutrients.

Combined nitrogen-balance data for 35 adults are being analyzed statistically to determine the influence of several factors upon nitrogen balances on diets containing the FAO pattern of essential amino acids and the patterns in nonfat milk solids, whole egg, oatmeal, peanut butter, and wheat flour. The studies were made under contract at four locations (Alabama, California, Oklahoma, and Wisconsin).

E. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York, in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds

of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and $3/4$ pound of fats and oils. The total money value of all food per person was \$8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma, and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service as were similar surveys reported previously.

A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next Nationwide survey proposed in the Department's long-range program.

The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U. S. per capita food consumption.

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using "recall questions", instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities, has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana, and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices, and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such popular publications as "Family Food Budgeting for Good Meals and Good Nutrition," through filmstrips ("Food for the Young Couple"), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions" has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs; (2) a report on fat and related components in U. S. diets; and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education," "Planning Nutrition Programs for Elementary School Teachers," and "Food Guides--A Teaching Tool in Nutrition Education."

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Nutrient Values of Poultry and Poultry Products

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Food Consumption and Dietary Levels

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Development of Food Budgets and Other Basic Data for Food and Nutrition Programs

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POULTRY - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. The \$1.6 billion poultry meat industry operates on very narrow profit margins. This industry is confronted with the problem of converting continually increasing amounts of poultry into a wide variety of products having high quality and improved convenience, at costs attractive to consumers and remunerative to the poultry grower. Information on the properties and processing of poultry is not sufficient to enable us to better utilize poultry in a variety of forms attractive to consumers. Increased utilization of poultry would also serve toward eliminating our feed grain surplus, increasing returns to farmers and providing better products for American consumers.

Although poultry is an efficient converter of feed to meat, more grain is used by poultry per calorie of food produced than by any other commercial animal because a high percentage of the poultry diet is grain and because poultry meat contains exceedingly little fat. Furthermore, one-fourth of all grain fed to animals is used for poultry and egg production. Hence, increased consumption of poultry products would be an effective means of increasing markets for surplus grain. Also, the efficiency of feed utilization by poultry makes possible low prices within reach of more consumers. A still further benefit would arise from the increased use of poultry by improving the nutrition of consumers having diets now low in animal protein.

The consumption of poultry has steadily increased from a 1947-1949 average of 22 lbs. per capita to 37 lbs. for 1962. This important increase has involved price, quality of product, availability, and disposable income. Because of the current low profit margin it is impractical to increase consumption by lowering farm prices. Increased demand for and consumption of poultry will require higher quality and more convenient products and a greater variety to meet the desires of the modern consumer. However, in addition to greater returns from increased demand, a greater profit margin for the farmer can, of course, come from greater efficiencies in processing.

The trend toward convenience foods and further processing has primarily led to precooked poultry products which are generally less stable, more subject to warmed-over flavors, and more likely to provide texture problems than uncooked items. With the expansion of operation and the emphasis on continuous, more efficient processing, need has arisen for improved processing procedures for feather removal, chilling, tenderization, freezing, deboning, and commercial cooking. Lowering the cost and improving the quality of products that can be stored at ambient temperatures, such as canned, dried, cured, and irradiated products, offer potential for poultry utilization in domestic and export markets. As a foundation for applied studies, further knowledge is needed on the chemical nature of flavor and flavor changes in processing and storage, on tenderness development, and on proteins, lipids, and other components.

USDA PROGRAM

Basic and applied research on poultry meat and poultry meat products are conducted at the Division headquarters at Albany, California and, by contract, in East Lansing, Michigan. Fundamental studies on poultry flavor are concerned with the identification of flavor precursor constituents in poultry meat and in the isolation and identification of volatile flavor components developed during the cooking of poultry. The chemistry of muscle protein and post-mortem chemical changes are investigated relative to the tenderness and other quality characteristics of poultry. The basic physiological character of feather release mechanism in fowls is studied to provide a foundation for improved feather removal. Applied research is conducted on the stability of cold-tolerant organisms; special problems of flavor, texture and stability of precooked frozen foods; and processing factors that influence tenderness of poultry meat.

The Federal program of research in this area totals 20.2 professional man-years, including contract research equivalent to approximately 0.9 professional man-years per year. Of this number, 9.4 are assigned to chemical composition and physical properties; 10.8 to new and improved food products and processing technology.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Flavor Chemistry. In basic studies on the flavor of poultry meat, emphasis is placed on the isolation and identification of constituents of the volatile fraction of poultry that has been cooked by various procedures. The object of these studies is to establish the relation between natural flavors or off-flavors, and these constituents, particularly those that occur in precooked, frozen, and canned poultry. Studies of the volatiles from fried chicken were completed. Results confirmed indications that off-flavor in processed chicken comes from an increase of natural components rather than a development of new components. This suggests that quality of poultry flavor is in large part a function of concentration of volatiles. For one volatile, hydrogen sulfide, it was shown that muscle proteins are the principal precursors. Non-proteins such as glutathione, taurine, methionine, and cystine contribute little to the total hydrogen sulfide released when poultry is cooked.

Tenderizing procedures, including aging of slaughtered chicken and ante-mortem adrenalin injection, were observed to affect chicken broth flavor. The treatments cause a small difference in acidity. However, in other tests, a pH adjustment of 0.4 pH unit upward or downward after cooking and a pH difference as great as 0.17 pH unit during cooking did not affect chicken broth flavor. Therefore, the flavor differences between tenderized and untreated chicken cannot be attributed to pH differences.

2. Post-Mortem Biochemistry and Tenderness. Basic investigations were conducted on the component proteins of poultry muscle and their reactions post-mortem which affect tenderness and other texture qualities. The pattern of tenderization in poultry is as follows: meat cooked a few minutes after slaughter is more tender than meat allowed to age for one hour before cooking. The transient period of initial tenderness before onset of rigor mortis, is difficult to demonstrate in poultry because the very act of cooking accelerates the metabolic processes in the meat. Rapidity of onset of rigor in young birds was not found necessarily to result in toughness. Chemical changes accompanying rigor mortis include breakdown of glycogen and adenosine triphosphate and increase in acidity. Glycogen breakdown was closely associated with the development of toughness. With the normal occurrence of glycogen breakdown, the meat rapidly becomes tough and remains tough until the aging process, in some unknown manner, renders the meat tender again. Acceleration of post-mortem glycogen breakdown in young poultry increases the toughness of fully aged meat. Injections of epinephrine or of iodoacetate prior to slaughter or very rapid cooking were tried to eliminate or reduce post-mortem glycogen breakdown. Meat from birds in which post-mortem glycogen breakdown was eliminated or inhibited is initially tender and remains so through a 24-hour aging period.

3. Physiology of Feather Release. The physiological mechanisms that control feather tightening and release in poultry are being investigated in contract studies at Michigan State University at East Lansing. The involvement of the nervous system in the mechanisms by which physical and chemical agents influence feather release, was studied. The direct involvement of the central nervous system was demonstrated by performing spinal section. The feather pulling force in the dorsal feather tract, posterior to the section, was markedly reduced, while there was little effect anterior to the section. When the disconnected end of the severed cord was stimulated electrically, the feather pulling force returned to its high normal value during the stimulus. A functional relationship between a nerve located just below the skin surface and the feather pulling force in the femoral feather tract was established in an anesthetized bird. The nerve that influenced feather release was traced back to the lumbar-sacral plexus. The failure of injected curare to alter plucking indicates that the skeletal voluntary muscles do not take part in the release of feathers.

B. New and Improved Food Products and Processing Technology

1. Low-Temperature Microbiology. Fundamental and applied research was conducted to determine growth, survival, and lethal conditions for microorganisms that grow at temperatures of 32° F. and lower. A literature survey on low-temperature microbiology was completed, a valuable convenience to other scientists, and a sound foundation for Department research. Freezing storage and repeated freezing and thawing of chickens were found to have no adverse effects on subsequent keeping time under refrigeration. Salt brine dips prior to freezing or refrigeration increased keeping time as much as 25%. Similar treatment in water containing 50 p.p.m. of free chlorine

increased keeping time by the same amount. Preliminary studies indicated that proper incubation temperature for bacterial plates used for bacterial analysis of chilled foods should be at a temperature close to that at which the food was stored, rather than at 35° or 37° C. as is commonly used. Long-term storage experiments with frozen chicken products inoculated with high levels of bacteria, were initiated to determine whether bacteria in a frozen product where they are not growing will affect storage stability.

Questions have been raised concerning the bacterial safety of cooked turkey rolls. Bacterial levels in the center of turkey rolls were reduced markedly during cooking. Counts were reduced to an insignificant level at center temperatures of 153° F. Cooking temperatures of 165° and higher are generally recommended for cooking this product.

The Department scientist specializing in low-temperature microbiology is serving on an international and two national committees concerned with the development of microbial standards for food products, thereby providing a first-hand advisory function in this specialized line of investigation.

2. Freeze-Drying of Poultry. A new investigation was initiated on the freeze-drying process which converts foods to a stable, lightweight form which may be easily reconstituted so as to be practically indistinguishable from the original state. Freeze-drying is now a substantial commercial operation. Its full potential can be achieved only by reducing cost, which is high because very good vacuum must be maintained and cycle times are extremely long for food pieces of the usual size. The object of the new work is to reduce processing cost, partly through reducing the drying cycle time, partly through reducing the cost of equipment. The ultimate goal is a cheap, continuous, high-capacity freeze dryer. Two engineering configurations are being explored. In both the mass of frozen pieces is tumbled in vacuum with radiant heat on them to sublimate ice. Basic design features are being explored. Upon completion of this work a prototype dryer will be designed and constructed for use on large experimental scale.

3. Tenderness and Other Textural Qualities. Use of polyphosphates in the water used to chill turkeys prior to freezing benefits frozen cooked meat stored at 10° F. for nine months. In chilling tests with frozen chicken fryers, polyphosphates were found to improve retention of water during refrigerated holding or cooking. Moisture uptake during slush ice chilling was reduced by the use of polyphosphates and spoilage during subsequent holding under refrigeration inhibited. It is presumed that chelation of trace metal compounds by the polyphosphates prevents bacterial growth.

Department work aimed at improving meat tenderness is being coordinated with that of research institutes. Several lines of attack have been taken up against the tenderness problem, including histological studies, studies of water binding and inorganic salt effects, changes in the solubility of protein, the role of enzymes, post-mortem glycolysis, effects of age, breed, sex, and feeding practices, and the influence of ante-mortem and post-mortem

handling practices and cooking methods. Coordination between agencies is one of the functions of the Institute of American Poultry Industries, whose research committee includes Department scientists.

4. Radiation Preservation of Poultry Products. Irradiation-sterilized poultry is considered potentially attractive to feed troops where refrigeration is not available. With funds transferred from the Department of Defense, Quartermaster Research and Engineering Command, evaluation of poultry preserved by several radiation treatments was undertaken. Major problems of flavor, color, and texture losses during processing and subsequent storage were revealed and means for controlling some of the damage were developed, particularly to protect color and flavor. Heat inactivation of enzymes and temperature control during radiation treatment eliminated a red discoloration and reduced off-flavors.

5. Precooked Frozen Poultry Products. It was also shown that starchy cereal thickening agents were effective in reducing the liquid exudation that commonly occurs during baking of prepared turkey meat loaves after freezing and frozen storage.

The freezing and reheating of fried chicken increases the tendency of the usual coating materials to peel off and become unattractive. Partial cooking shrinks the meat before the batter is applied so that the coating adheres to the meat through freezing, thawing, and reheating. Both shrinkage of the meat during cooking and the pressure of escaping moisture tend to loosen coatings. Research demonstrated how batter ingredients can be varied to obtain desired thickness, crispness, and color. Results can be applied by processors to develop a variety of coatings that will provide the adhesive quality, thickness, appearance, and consistency needed to increase the value of fried chicken and other breaded frozen products.

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EGGS - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. The \$1.8 billion egg industry is periodically faced with burdensome surpluses that drive prices below the break-even point for many producers. The industry is also faced with declining per capita consumption. The estimate for 1963 is down 18% from the 1947-1949 average consumption. Because the demand for table eggs is inelastic, the increased utilization of eggs must come in the form of new egg products that compete by means of quality and convenience. Adequate knowledge is lacking of the properties, processing characteristics, and new product potentials of eggs to develop new markets. Present outlets for the 10% of egg production that is frozen or dried include the baking, confectionery, salad dressing, noodle, and baby food trades. Modified and new products emphasizing quality and convenience are needed to increase acceptance of egg products by these industries in order to compete successfully with egg substitutes.

Increased utilization of eggs would not only benefit the producer, but would also diminish our feed grain surpluses since poultry and egg production account for about one-fourth of all grain fed to animals. Improved egg-containing products would benefit the producer in three ways: by providing an increasingly useful buffer for stabilizing egg prices; by providing additional uses and outlets for eggs; and by providing more remunerative outlets for wholesome eggs that are unsuitable for table use because of appearance or handling characteristics.

Egg processors have four general problems. First, the potential of yolk-containing solids in convenience foods can be fulfilled only with improvement of flavor stability, of dispersibility, and freedom from pathogenic Salmonella bacteria. Secondly, the processing costs of whites must be reduced and their utility improved in order to dispose of whites which accumulate in surplus because of the demand for yolks. Third, further basic research on egg composition and components is essential to reach an understanding of physical and chemical changes induced by processing and storage and thus provide a rational basis for devising improved processes and products. Fourth, formulation studies designed to incorporate eggs into new household and institutional convenience products, are needed. This last study must encompass a full appraisal of physical, chemical, and microbiological problems peculiar to the formulated products.

USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research is conducted at the Division headquarters at Albany, California; by contract in Austin, Minnesota, and Ames Iowa; and by grant funds under P.L. 480 in France and India. Fundamental research is

conducted on egg proteins and their relations to the functional properties and quality of eggs, on egg lipids and their role in off-flavor development in yolk solids, on the mechanism of bacterial penetration and survival in eggs, and on the bactericidal, antiseptic, anti-inflammatory, and food preservative properties of lysozymes and other components from eggs. Applied research is conducted on the stabilization of yolk-containing solids to increase the usefulness of eggs in dry mixes and other convenience foods, on new and improved drying procedures to make dried egg fractions and products more readily and more completely dispersible, on various methods of controlling Salmonella in eggs, and on factors in the handling of shell eggs that affect egg product quality and cost.

The Federal program of research in this area totals 18.6 professional man-years, including contract research equivalent to approximately 0.9 professional man-years per year. Of this number, 6.3 are assigned to chemical composition and physical properties, 12.3 to new and improved food products and processing technology. In addition, two research grants on basic problems are supported by P.L. 480 funds.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Egg Proteins. Basic investigations on lysozymes from various sources, including eggs, are conducted at the University of Paris, France, supported by P.L. 480 funds. Lysozymes are enzymes with bactericidal and anti-inflammatory properties. The amino acid composition of egg lysozymes has been compared with lysozymes from a number of other animal sources, including poultry. Lysozymes were found to vary in biological activity; those having greater activity contain more basic amino acids. Substrates for the enzymic action of lysozyme are being isolated and analyzed as a step towards the elucidation of the relationship between chemical structure and biological activity of lysozymes. Lysozymes were purified from the egg white of duck's and hen's eggs. Comparative studies are under way using lysozymes from bacterial and other animal sources.

2. Bacterial Spoilage of Shell Eggs. Basic research on spoilage of shell eggs is continuing. Dilution techniques used in the laboratory counts of various Pseudomonas species which are involved in egg souring, were modified using peptone water as a diluent, in order to eliminate the killing effect of various other dilution media. The killing effect of dilution media in bacteriological population counts was connected with minor traces of copper. Removal of this heavy metal by redistillation, ion exchange, or treatment with hydrogen sulfide followed by filtration eliminated the destructive effect. Pseudomonas species were found to be especially susceptible to heavy metal contamination, while other food spoilage bacteria are not sensitive to copper in the concentrations found in distilled water from a piping system.

The contribution of metabolic products of egg spoilage bacteria to the bacteria's ability to infect eggs is being investigated. A fluorescent pigment is excreted by the Pseudomonad egg spoilers and the presence of this pigment is used to detect eggs infected and spoiled by these bacteria. This pigment was purified and preparations isolated in suitable quantities for chemical study. At least four separate compounds are present in the fluorescent pigment. All four of the separated compounds bind ferric iron ions. This observation lent support to the hypothesis that iron-binding compounds excreted by spoilage bacteria counteract the antibacterial iron-binding action of conalbumin and other proteins of egg white. The Pseudomonad species from which the pigment had been obtained is unable to grow in egg white, because the small amount of iron required for growth is complexed with the protein, conalbumin and unavailable to the bacteria. However, supplementation of egg white with as little as ten micrograms per milliliter of a crude but iron-free pigment preparation obtained from growing bacteria, was followed by extensive growth of the bacteria. It is now thought that the pigment can recapture iron from the conalbumin complex and hold it in a form that is available to support bacterial growth. These findings explain the mechanism by which Pseudomonads infect and spoil eggs. Infection on the shell and at membranes is a common occurrence. Growth of bacteria at the membranes results in the formation of the pigment which diffuses into the white. The presence of the pigment therein permits extensive multiplication of the bacteria and spoilage of the egg.

3. Oxidative Changes in Yolk Lipids. Basic studies are conducted by contract at the Hormel Institute of the University of Minnesota aimed at elucidation of the oxidative mechanism of egg lipid systems to serve as a basis for interpreting and correcting undesirable oxidative flavor deteriorations induced by processing and storage of eggs. Lecithin prepared from fresh eggs exerted an antioxidant effect when added to egg powders to be stored. In contrast when lecithin was prepared from egg powders that had been stored it had a pro-oxidant effect on the autoxidation of methyl linoleate. Preliminary studies indicate that carotenoids in eggs also exert a pro-oxidant action on the egg lipid system. An improved laboratory technique to recover volatiles from stored egg powders has been developed to measure oxidative changes as egg products are stored.

B. New and Improved Products and Processing Technology

1. Egg Powders. Dispersion and rehydration were materially advanced by gas-impregnation spray drying. A gas impregnating system compatible with continuous spray drying on high-capacity equipment was developed and successfully applied to egg yolk using carbon dioxide, nitrous oxide, or gaseous nitrogen. Modifications permit wide variation in particle sizes and bulk densities of products. Particles over 1000 microns in diameter and powders having a bulk density of less than 0.1 gram per ml. have been readily obtained. Free-flowing, whole egg powders of improved dispersibility were found to perform better in layer cakes and cookies than those agglomerated after drying or dried at atmospheric pressure after being whipped into a foam.

2. Control of Salmonella in Egg Products. Three aspects of research and development are involved in Salmonella control in processed egg products. First is research toward more reliable analytical methods that can be used to determine whether or not viable Salmonella exist in any product; secondly, a study of the bacteriological factors, including degree of contamination and conditions of pasteurization necessary to kill organisms; and finally an investigation of changes in flavor and functionality of egg products for baking and other uses, that are caused by heat treatments to control the bacteria.

Improved heat treatments and equipment are sought to kill Salmonella in eggs under conditions which do not damage the eggs. Steam infusion and conventional plate heating and holding tube equipment were both used to pasteurize liquid egg. Application of direct steam infusion to flash heat whole egg to 160° F. for less than 5 seconds, followed by vacuum flash cooling to 125° F. destroyed inoculated Salmonella of average heat resistance in whole egg at about 1000 viable organisms per gram. This heat treatment did not cause significant baking function loss in either frozen or spray dried products. Steam infusion heating of egg liquid appears promising as a means of reducing bacterial contamination of egg products. However, demonstrations are still to be conducted on commercial-scale equipment under normal processing conditions.

Dried egg white is stable at ambient temperature only if reducing sugars have been removed prior to dehydration. One method of removing reducing sugars is to ferment liquid egg white with bacteria. Such fermentations, when controlled, limited the development of Salmonella in egg products. An alternate method for minimizing the reducing sugar-induced protein deterioration and discoloration also inhibits Salmonella. Addition of table sugar or other suitable carbohydrate and adjusting the pH of the liquid egg white improved storage stability and prevented discoloration of stored dried egg white, but slightly diminished functional properties. This method, like fermentation desugaring would be of use where freedom from Salmonella was more important than maximum performance quality.

4. Precooked Frozen Egg Products. Principles governing the behavior of essential basic ingredients in foods that influence their suitability for use in prepared and precooked frozen foods are under investigation. Special emphasis is placed on the foaming, emulsifying, thickening, binding, and gelation properties of eggs and cereals since products having structures involving these properties are particularly susceptible to freezing damage. The relation of solids content to stability of foam products, such as soufflés, is being investigated. Soufflés with high solids maintain their volume through freezing and reheating, although soufflés with lower solids had a greater volume than those with higher solids content immediately after baking. However, their volume diminished on reheating after they had been stored at 0° and 10° F.

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1/ Research supported by P.L. 480 funds.

III. MARKETING AND ECONOMIC RESEARCH

POULTRY PRODUCTS - MARKET QUALITY
Market Quality Research Division, AMSProblem.

New technological developments in the poultry industries have created many problems relating to the market quality of poultry and egg products. The introduction of highly mechanized equipment and new techniques in processing have had variable effects on the absorption and retention of moisture of ready-to-cook poultry, on the contamination of poultry and egg products by spoilage micro-organisms, on physical damage to poultry carcasses, and on sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more precise information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

USDA PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, and at Athens, Georgia, in cooperation with the Georgia Experiment Station and through a research contract with the University of California, Davis, California, on the effect of various disease syndromes on the wholesomeness of market poultry.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years, about equally divided between objective measurements and evaluation of quality, and handling and packaging.

Studies on the quality retention of dressed poultry as related to method of washing and cooling (MQ 2-10) were terminated during this period.

A. P. L. 480 grant with The Ministry of Agriculture, Spain, provides for a study of the relation of changes in chemical and biological properties of lysozyme to changes in quality of shell eggs held in cold storage. Its duration is for 3 years, 1960-1963, and involves P. L. 480 funds with a \$17,094 equivalent in Spanish pesetas.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality measurement and evaluation of quality

1. Effect of Various Disease Syndromes on Wholesomeness of Market Poultry. (carried out under contract with the University of California, Davis, California.)

Five experimental trials, designed to evaluate the pathogenic action of various combinations of disease agents in chicken fryers, were completed. Each trial consisted of inoculating 25 birds in each of 5 different age groups (total 125 birds) with the infective agents and then sacrificing all birds at the market age of 10 weeks for post mortem examination. The infective agents were (1) Newcastle disease virus (B₁ strain) and Escherichia coli (serotype 1-1), (2) infectious bronchitis virus (IBV) and E. coli, (3) IBV and Hemophilus gallinarum, (4) IBV and Mycoplasma gallisepticum (PPL0), and (5) PPL0 and Newcastle disease virus.

In four of the five trials, the combinations of agents and the times and methods of infection tested thus far have not been successful in producing disease syndromes typical of those encountered during routine official inspection, particularly those involving extensive air sac involvement. The expected disease syndrome was obtained in all trials but the lesions were for the most part resolved prior to slaughter except for the IBV and Hemophilus gallinarum. A series of pilot trials using over 35 different combinations of infective agents, times, and methods of inoculation yielded information which will serve as a basis for additional trials with fryers. This study has thus far demonstrated that accepted concepts regarding the etiology of air sacculitis in chicken fryers may need to be modified.

(MQ 3-22(c))

2. Assessing the Sanitary Quality of Commercial Egg Products.

Bacteriological examination of more than 40 samples of commercial whole egg, yolk, and egg white solids was completed. Analysis of the data revealed that there were significant correlations between

the log of the standard plate count and the log of the enterococcus count. Correlation coefficients were 0.84, 0.97, and 0.95 for whole egg solids, egg white solids, and yolk solids, respectively. In every instance, enterococci outnumbered the coliforms, with numerous samples containing less than 10 coliforms per gram but relatively large numbers of enterococci. These results indicate that an enterococcus count should be a better index of the sanitary quality of dried egg products than a coliform count. A study in a commercial egg processing plant showed that the enterococcus count would also be a satisfactory indicator of sanitary quality of liquid egg and frozen egg. Studies with a dye reduction test utilizing resazurin and various tetrazolium compounds as a method for more rapid estimation of sanitary quality of liquid egg products were also initiated.

(MQ 3-31)

3. Methods to Evaluate Shelf-life of Eviscerated Poultry. A relationship was found between the bacterial content of drip from cut-up tray-packed poultry and the concentration of bacteria on the surface of the breast contained in the same package. The study indicated that each of the following methods may be used to obtain an approximation of the growth of microorganisms on cut-up tray-packed poultry meat during storage: (1) from individual lots of tray-packs determine the number of bacteria per ml. of drip from a different package each day; (2) determine number of bacteria in one milliliter of drip from the same package on successive days; (3) remove all drip from the same package on successive days and determine the number of bacteria per ml.; (4) on the first day of storage, place all drip from a representative package into a test tube, maintain the tube at the same temperature as birds and sample the drip from it on successive days for bacterial count. When these methods were compared to the actual total aerobic count on the breast of different chickens (swab technique) on successive days, the correlation coefficients obtained were 0.9, 0.9, 0.8, and 0.9, respectively. The importance of these findings is that (a) an indication of shelf-life of packaged birds may be obtained with fewer samples than was previously necessary; (b) errors due to bird-to-bird variations can be reduced and; (c) sampling of drip can be carried out repeatedly with only minimal effect on the package and no effect on the poultry meat.

(Exploratory Work--Project Pending)

B. Quality maintenance in handling and packaging

1. Airborne Microorganisms in Broiler Processing Plants. Airborne microorganisms were determined in two poultry processing plants using Anderson samplers and a mobile power supply. Total aerobic bacterial counts were highest in the dressing room with diminishing numbers in the shackling, eviscerating, and holding rooms when sampling was carried out during plant operation. The average counts per cubic foot of air in these four rooms were 2,200; 560; 230; and 62, respectively. As would be expected, the number of molds, coliforms, enterococci, psychrophiles, and total aerobic bacteria increased in the shackling and dressing rooms once processing was begun. Average total aerobic bacterial counts taken at 5:00 a.m. (before plant operation began), 9:00 a.m. and 2:00 p.m. increased from 70 to 870 to 3,000 respectively in the shackling room and from 310 to 4,900 to 7,000 in the dressing room. Airborne molds probably originate from a source other than the poultry being processed.

(MQ 2-10)

2. Influence of Polyphosphates and Other Compounds During Chilling on Quality of Eviscerated Poultry. A study was completed on the experimental effects of sodium polyphosphates on weight of fryer chickens during chilling. Phosphate-treated chickens gained less during chilling than control chickens, but when weighed after 24 hours, both groups showed about the same gain, indicating less moisture loss in the phosphate-treated birds. If continuous chilling preceded a 6-hour soaking period (in either phosphate solutions, plain water, or NaCl solutions), the moisture absorbed by chicken carcasses usually exceeded the limits established by USDA. Birds which exhibited a low percentage gain in weight during chilling, lost less moisture and for a shorter period of time after chilling than birds which showed a high percentage gain. Sodium chloride (ordinary salt) in amounts permitted by USDA in chilling media had no significant effect on moisture pickup. Birds chilled at pH 10 showed a significantly higher percentage gain in weight than birds chilled at pH 3,5,7,8, or 9. Within the limits of this study, neither time of air agitation, nor temperature, of the chilling media significantly affected percentage gains. This project was terminated.

(MQ 2-10)

3. Relation of Broiler Part Size and Weight to Carcass Weight. In a cooperative study with the Transportation and Facilities Division, a study to determine the relations of weights and sizes of broiler

parts to carcass weights was conducted. In the study, a large number of broilers were cut up, and the weights, volumes, and dimensions of the parts measured. Weight, volume, and dimensions of broiler parts can be predicted with reasonable accuracy if the carcass weight is known. Sizing of the carcasses can be used as a basis for providing uniform parts for portion-control packages (each package containing parts of the same size), and for convenient selection of parts to make up packages of an exact weight. The percentage relationship of weights of parts to the carcass weight was found to be approximately the same for all weight groups.
(MQ 2-41)

4. Eating Quality of Ice-Packed and Frozen Chicken. In a study dealing with organoleptic acceptance of ice-packed and of frozen chicken, a laboratory panel evaluated light and dark chicken meat from halves of the same chicken ($\frac{1}{2}$ ice-packed; $\frac{1}{2}$ frozen) over a 14-day storage period. There was a small but consistent preference for flavor of frozen light meat over ice-packed after the third day of storage. The same trend was evident in dark meat but the degree of preference was much less. Differences in juiciness and tenderness scores between treatments were very small.

In a second study, a home consumer taste panel was set up in which 74 families in the Athens, Georgia, area participated. Participants were chosen at random and were asked to evaluate two chicken halves as to various characteristics. One-half of each chicken had been frozen, then thawed, whereas the other had been ice-packed. Two halves of a chicken were delivered to each family each week for 3 weeks. Provisions of the study were set forth in an instruction sheet. Upon evaluation of the samples, each family returned a report card of their preferences, cooking method used, and reason for preference of one sample over the other. It was found that there were more participants (about 7 percent), who chose the fresh samples over the frozen. In the first and second week, about one-third of the participants could not differentiate between the halves. In the third week, a greater number of participants than previously could differentiate. The combination of "Taste and Tenderness" was the largest category for reason of choice. Cooking technique was found to have no significant effect on the reasons for choice.
(MQ 2-41)

5. Capillary Fragility and Bruise Healing of Broilers. Studies on the effect of oral intake of ascorbic acid and hesperidin on capillary fragility and bruise healing of broilers were not clear

cut. Further work is needed. Hesperidin showed some promise in reducing bruise incidence in commercial handling. Ascorbic acid appeared to cause some reduction in strength of capillaries but significantly reduced healing time of bruised birds.

(MQ 2-41)

6. Quality Retention of Eviscerated Poultry as Related to Method of Slaughter. A prototype apparatus for slaughter of poultry was designed, constructed and is being tested to determine whether better control of bleeding during slaughter of chickens can be obtained. The apparatus consists of a plunger device for stunning the bird by skull penetration similar to that used on larger meat animals. It differs in that vacuum is applied through the hollow plunger after penetration to enhance blood removal.

(MQ 2-81)

7. Changes in Eggs During Cold Storage. The effect of storage for up to 10 months at 0° C., 85-90% R. H., and 2° C., 90-95% R. H., on egg quality was studied under a P.L. 480 grant in Spain. No important differences were found as a function of these temperature and relative humidity conditions. Under both, the proportion of thin albumen increased and Haugh units decreased, and thin albumen viscosity and lysozyme activity showed no consistent pattern of change.

Microbiological studies showed that Penicillium was the mold in greatest occurrence during storage, and that the isolation of Pseudomonas increased in frequency during storage. Lysozyme, both in-vitro and on-site, proved to have very slight, if any, effect against Pseudomonas.

Oiling was superior to plexiglas, which in turn was superior to no shell treatment, in maintaining quality.

(E25-AMS-5(a))

8. Rancidity in Cooked Poultry. The effectiveness of polyphosphates in delaying rancidity development in commercially processed and cooked fryer chickens was investigated. Analysis of the data is in progress.

(Exploratory work - no line project)

9. Shelf-life of Prepackaged Cut-up Poultry. Prepackaged cut-up fryer chickens which had been frozen for 3 months and then thawed were evaluated to determine if differences in shelf-life could be

discerned when five different types of overwraps were used. Overwrapping material studied included: Polyethylene (1 mil); Polyvinyl Chloride (1 mil); Irradiated Polyethylene (1 mil); Polypropylene (1 mil); and Polyvinyl Chloride ($\frac{1}{2}$ mil). There was no significant difference between the bacterial counts on the breast or in the drip that could be attributed to differences in type of overwrap. Average shelf-life of the five groups, placed in a 34° F. cooler in a frozen condition, was about 26 days. The percentage drip increased with the increased storage (significant at 1% level) but no difference in the amount of drip resulted from differences in overwraps.

(Exploratory Work--Project Pending)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

Tarver, F. R., Jr., May, K. N., and Boyd, F. M. 1962. Sampling technique for the enumeration of microorganisms in the diverticulum of the anterior thoracic air sac of chickens. Applied Microbiology, 10: 137-140. (MQ 3-22(c))

Walters, R. E., and May, K. N. 1963. Thermal conductivity and density of chicken breast muscle and skin. Food Tech. 17: 808-811. (MQ 2-41)

Walters, R. E., May, K. N., and Rodgers, P. D. 1963. Relations of weights and sizes of broiler parts to carcass weights. Marketing Research Report No. 604. (MQ 2-41)

Quality Maintenance in Handling and Packaging

Kotula, A. W., Thomson, J. E., Novotny, J. F., and McNally, E. 1963. Bone darkening in fryer chickens as affected by calcium and phosphorus levels in their diet. Poultry Science 42(4) pp. 1009-1014. (Exploratory work--no line project)

Kotula, A. W. 1963. Poultry slaughter techniques - a review. The Maryland Poultryman, July, p. 2-5. (MQ 2-81)

May, K. N. 1962. Bacterial contamination during cutting and packaging chicken in processing plants and retail stores. Food Tech. 16(8): 89-91. (MQ 2-10)

May, K. N., Helmer, R. L., and Saffle, R. L. 1963. Effect of phosphate treatment on carcass weight changes and organoleptic quality of cut-up chicken. Poultry Science 42: 24-32. (MQ 2-41)

Tarver, F. R., and May, K. N. 1963. The effect of bleed time prior to scald and refrigerated storage upon bacterial counts in the diverticulum of the anterior thoracic air sac of chickens. Food Tech. 17: 198-200. (MQ 2-10)

Thomson, J. E., Kotula, A. W., Novotny, J. F. 1963. Experimental effects of sodium polyphosphates on weight of fryer chickens during chilling. Marketing Research Report 605. 15 pp. (MQ 2-41)

POULTRY AND EGGS - MARKETING FACILITIES,
EQUIPMENT, METHODS AND SHIPPING CONTAINERS
Transportation and Facilities Research Division, AMS

Problem. A rapid increase in the production of poultry and eggs in the United States in recent years and an accompanying increase in total consumption has resulted in significant changes in marketing methods and requirements for these products. These changes have had an impact on poultry processing and egg grading and packing plant facilities and equipment requirements, as well as in operating methods. Problems in this connection generally have been worked out by industry on individual plant basis. In the main, the answers have furnished only a temporary solution to expansion needs and little help in developing guidelines for new plants or solving production problems. In order to improve operating efficiency in existing facilities, and provide guidelines for plant expansion or for new facilities, with due consideration for product quality; more efficient work methods, plant layouts, devices and equipment, and improved facility designs are needed for commercial handling, processing, grading, and packing of poultry and eggs to increase labor productivity, reduce nonlabor inputs, improve yield without lowering quality, and minimize construction and maintenance costs.

It costs about 8 billion dollars a year to package food products, but without shipping containers and various other types of packages it would be impossible to move farm products efficiently from the widely dispersed areas of production through our complex marketing system to millions of consumers. New or improved packages and containers must be developed and evaluated to do this job more effectively. In protecting, distributing and selling perishable agricultural commodities, packages and containers must respond to a number of marketing system changes.

USDA PROGRAM

The Department has a continuing long-term program involving engineers and marketing research analysts engaged in both basic and applied research to develop more efficient work methods, techniques, operating procedures, devices, and equipment and to design improved facilities for the handling and preparation for market of poultry, eggs, and egg products. Research on poultry-processing operations is carried on by Department personnel at Athens, Ga., in cooperation with the Georgia Agricultural Experiment Stations and, near the end of the report year, was initiated at Davis, Calif., in cooperation with the California Agricultural Experiment Station. Contract research to develop improved poultry processing equipment was conducted by the Gordon Johnson Company at Kansas City, Mo., and at Gainesville, Ga., in cooperation with J. D. Jewell, Inc. Department personnel in the Washington office conduct research relating to shell egg grading and packing systems and the design of warehouses for poultry and egg wholesalers.

Contract research on shell egg cleaning techniques and equipment is conducted by the University of California at Davis, Calif. Research to develop engineering designs for egg grading and packing plants, which was initiated at Davis, Calif., near the end of the report year, is cooperative with the California Agricultural Experiment Station.

The Federal effort devoted to research and development work in the area of marketing facilities, equipment and methods totals 7.0 professional man-years annually: 3.6 man-years (including 0.6 man-year of contract work) on poultry, 2.3 man-years (including 0.6 man-year of contract work) on shell eggs and egg products, and 1.1 man-year on program leadership.

Federal effort in the area of consumer packages and shipping containers involves 9 professional man-years, of which 0.8 is devoted to poultry.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Improved Methods and Equipment for Eviscerating Chickens

This long-term research program, at Athens, Ga., which is cooperative with the Georgia Agricultural Experiment Stations, involves the development of improved methods, operating procedures, and equipment for eviscerating chickens. Studies evaluating work methods and equipment and determining labor requirements for eviscerating operations in plants under official U.S.D.A. inspection were carried out through use of time and motion studies and other industrial engineering techniques. Improvements in work methods, equipment, and work station layouts were developed. The results reported in Marketing Research Report No. 549, "Methods and Equipment for Eviscerating Chickens," showed that efficiency can be increased by: (1) Adopting work methods that avoid frequent loss of small quantities of edible product; (2) improving work station layout so as to permit higher productivity per worker with less fatigue; and (3) balancing crew size with the speed of the production line.

Operations in most plants involve different processing rates for the various steps in preparing the product in ready-to-cook form and require frequent manual transfer of birds between production lines operating at different speeds. This operation not only requires much additional labor, as many as 8 or 10 workers in large volume plants, but also creates serious production "bottlenecks" which slows down or from time to time stops some operations altogether. A monorail conveyor capable of operating at different line speeds simultaneously; through the use of the power-free principle, intermittent storage loops, and selective switching devices; appeared to be a means of reducing these inefficiencies. A laboratory-scale model was constructed and tested. Limited tests show that such a conveyor line for poultry processing operations is feasible and that it should eliminate a number of production "bottlenecks" and much labor auxiliary to processing operations. At the end of the year a report setting forth the principles and line specifications was being prepared for publication.

B. Methods, Equipment, and Facilities for Grading and Packing Eggs

This research, conducted by the Washington office, is directed toward reducing egg marketing costs through engineering analysis of existing work methods, equipment, and facilities for handling, cleaning, grading, shell treating, and packing eggs and by developing and testing improvements.

Field work to obtain data for evaluating the latest mechanized egg grading and packing systems has been completed. A comparison of labor and equipment requirements for these systems was undertaken as the basis for the preparation of a report.

C. Improved Designs for Wholesale Poultry and Egg Distributors' Warehouses

This research, conducted by the Washington office, involves an evaluation of existing warehouse facilities, layouts, and equipment problems of independent wholesale poultry and egg distributors in four large metropolitan areas and the design of improved facilities. Findings disclosed that facilities in use were not designed to handle the services being rendered and, because of the age and building construction, installation of improvements calling for drastic modifications to meet present-day specialized service requirements are not feasible. Engineering designs and layouts were developed for multiple-occupancy facilities capable of handling combinations of operations involving: (1) Shell egg grading and packing as a principle operation and egg breaking and freezing facilities as an auxiliary operation, and (2) handling frozen and icepacked poultry, including cutting-up and packing ice-pack poultry, as a principle operation and grading and packing small lots of shell eggs as an auxiliary operation. These layouts will not involve major modifications in the type of structure now recommended by the Division for food terminal centers. They are also applicable to a conventional detached structure, thus permitting both a choice as to location and a choice of the combination of services to be offered. This research has been completed and a final report was in the process of publication at the end of the year.

D. Improved Methods, Techniques, and Equipment for Cleaning Eggs

This research, carried on under contract with the University of California at Davis, involves the development of improved methods, techniques, and in-line equipment that will do an effective job of cleaning shell eggs with minimum of quality deterioration, breakage, and labor inputs. The practice of wet cleaning eggs destined for table consumption has increased at a rapid rate throughout the United States. The methods, techniques, and equipment now employed are costly in terms of labor and breakage, high in egg spoilage hazard, and do an ineffective job of cleaning.

Laboratory tests determining safe time and temperature differences required between the temperatures of the egg and the washing medium have been completed. Findings show that a 20° F. temperature difference is necessary to reduce spoilage hazard to a minimum. The findings also verify a recent study showing that spoilage rates increase sharply when trace quantities of iron occur in the washing media. A technical paper reporting these findings has been published. A number of commercial egg cleaners have been field tested. Results show that none of the cleaners do an effective job of cleaning, several induce egg spoilage, and others cause an excess amount of breakage.

An analysis of these results established a realistic objective for the selection of an effective cleaning technique and provided guidelines for the structural requirements of an efficient in-line cleaner. Working drawings for an experimental in-line egg cleaner were submitted by the contractor and approved. Construction of the prototype cleaner also was completed and tests to determine optimum line and component speeds, combinations of detergents, and cleaner effectiveness were conducted. Keeping quality tests at laboratory level were underway at the end of the year. A technical report documenting laboratory procedures, findings, and resulting recommendations also was being prepared at the end of the year.

E. Improved Methods and Equipment for Cutting Up and Packing Chickens

In packing chicken parts to an exact premarked package weight, much time is presently wasted in selecting the last piece of chicken to fill a container because the choice is made on a trial and error basis. Frequently, excess weight is packed in a container because a chicken part of the desired weight is not readily available. Research in this chicken processing area is directed toward reducing the labor requirements and the losses due to packing errors. In order to effect these reductions and to minimize product contamination through frequent rehandling, mechanical sorting of parts by weight was studied at Athens, Ga., together with the entire cut-up operation. A study of the relationship of chicken carcass size to the weights of individual parts was completed and reported in MRR No. 604, "Relations of Weights and Sizes of Broiler Parts to Carcass Weights." Using data from the report, processors should be able to predetermine the most desirable carcass size of chickens yielding the best combination of parts weight for a given container net weight.

Under a research contract with the Gordon Johnson Company, Kansas City, Mo.; the design, construction, and laboratory testing of a mechanized chicken parts sizing and packing line was completed. In cooperation with J. D. Jewell, Inc., Gainesville, Ga., the experimental line was successfully field tested. Preliminary analysis of the test data show that reductions in labor required and losses due to packing overweight was sizeable; but that relatively high initial costs of the equipment may tend to retard its adaptation for commercial operations. A report was being prepared at the end of the year.

F. Improved Designs for Chicken Processing Plants

The rapid growth of the poultry industry has resulted in building additions and frequently makeshift construction without sufficient regard to or utilization of space. New structures have frequently included errors in building design and layout because of an absence of basic guidelines. This research, at Athens, Ga., involves the development of principles for improved plant designs and layouts, conducive to maximum efficiency at minimum cost for new construction or alteration. Plant designs, layouts, and plant operating conditions in a number of large chicken processing plants were evaluated and checked against facilities meeting U.S.D.A. inspection requirements.

Findings developed in previous Department studies, involving equipment layout for packing and eviscerating operations, plus information from engineering textbooks and other publications on plant layout practices are serving as aids in screening out inefficiencies and undesirable features. A manuscript draft covering overall layout requirements, the layout of each work area, and the development of a plant design conducive to efficient operations and economic expansion was nearing completion as the report year ended.

G. Improved Methods, Equipment, and Facilities for Chilling, Weighing, and Packing Turkeys

This research is part of a long-term program initiated at Davis, Calif., in cooperation with the California Agricultural Experiment Station, near the end of the report year. It will deal with the development of improved methods, equipment and facilities for chilling, weighing, and packing turkeys, and is comparable to the research carried on in chicken processing plants.

Because of the relatively long chilling time required after the turkey eviscerating operation, differences in packing rates, and recent changes in packing methods; the packing area in most turkey processing plants forms a "bottleneck" in product flow and is a direct cause of inefficient labor, equipment, and space utilization. In addition, weepage and weight differences occurring between the time of wrapping and freezing creates a major problem in marked weight compliance and in the appearance of the finished product. Based on the evaluation of existing methods and the development of improved work area layouts, handling and processing methods, this research will be directed toward alleviating the costly production "bottleneck", eliminating unsightly weepage between wrapper and carcass, and minimizing the weight losses sustained through inaccurate estimates of product "shrink" between wrapping and freezing. Work during the report year was limited to the development of work plans for the project.

H. Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

This research also was initiated at Davis, Calif., near the end of the report year, in cooperation with the California Agricultural Experiment Station. It is directed toward the development of improved designs and layouts for small-scale egg grading and packing plants, including engineering drawings and building specifications for selected typical installations. As the number of large-scale commercial egg production units in the U. S. has increased, a need has developed for structural designs and layouts for small egg grading and packing plants located at or near the source of production, designed to handle the output from one, two or three large commercial flocks. Many of these plants are now located in buildings that were not designed for this type operation.. As a direct result, the economic advantages that large lots of uniformly fine quality eggs offer, through mechanized handling, are frequently lost, product quality is exposed to the hazards of improper environment, and labor and equipment utilization is poor. Work during the report year was limited to the development of work plans.

I. Improved Methods, Equipment and Facilities for Preparing Turkey Specialty Items

The third project initiated at Davis, Calif., in cooperation with the California Station, toward the end of the report year, is directed toward the development of guidelines for improved methods, equipment, and facilities for "further processing" of ready-to-cook whole turkey. In recent years the trend toward preparing turkey specialty items in turkey processing plants designed only for slaughter, defeathering, evisceration and chilling has increased rapidly. Cut-up operations, deboning, preparing turkey logs and other specialty items have frequently been carried on in overcrowded make-shift facilities, employing methods and equipment of questionable value. This has resulted in production "bottlenecks," high labor input and frequently a hazard to product quality. Through process and method analysis, study of flow patterns and materials handling needs, improvements in processing area layouts will be developed, improved methods will be developed, tested and evaluated in order to provide an efficient economic diversion of product into, through and out of the "further processing" area. Work during the report year was limited to the development of work plans.

J. Improved Methods, Equipment and Facilities for Improving Chicken Processing Plant Efficiency through a Balancing of Inspection and Eviscerating Operations

This study will be carried out under a research contract with assistance from the Athens, Ga., office on contract administration. It will be directed toward increasing chicken processing plant efficiency and reducing the Department's costs in carrying out official inspection in chicken processing plants. Research findings reported in MRR 549, "Methods and Equipment

for Eviscerating Chickens" showed that maximum utilization of eviscerating crew labor was reached at different production levels for certain combinations of equipment and crew sizes and composition. Extending production beyond these optimum rates not only decreased the output per plant worker, but frequently required additional inspection personnel whose time is not fully utilized. Through the application of findings reported in MRR 549, and by conducting similar studies of inspection operations, analyzing production line speeds, types of equipment and processing crew makeup as these are interrelated, guidelines for balanced operations will be developed for specified production levels while attaining maximum equipment and floor space utilization and maintaining an acceptable level of workmanship. Work during the report year was limited to drafting contract specifications.

K. Shipping Containers

A report was published describing a new, inexpensive shipping container for short hauls of fresh-dressed ice-packed poultry. The container, a reusable wirework basket with a tough film liner, was designed and developed by USDA researchers. Assuming a life of 35 round trips, the number successfully completed in evaluation tests, the cost of the basket, a single-use liner, and the direct labor to pack was 64 cents less per 100 pounds of chicken delivered than the cost of the conventional wirebound crate. Use of the basket is considered advantageous only when the packer can control its return to the plant. Control is assured when the plant delivers in its own trucks to nearby markets but is not usually feasible in longer hauls by rail or by trucks not owned or leased by the plant. Other studies in this field seek to determine the advantages and disadvantages of marketing chickens cut-up, prepackaged, and frozen at processing plants as opposed to marketing fresh, ice-packed chickens and prepackaging them in retail stores.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Improved Methods, Techniques, and Equipment for Cleaning Eggs.

Brant, A. W., Starr, P. B. 1962. Some Physical Factors Related to Egg Spoilage. Poultry Science. October 1962.

Hamann, J. A. 1963. In-Plant Egg Washing. A technical paper presented at the Neppco Quality School, Maryland University, College Park, Maryland, June 1963.

Improved Methods and Equipment for Eviscerating Chickens.

Childs, R. E. 1962, The Chicken Eviscerating Operation. Poultry Processing and Marketing, October 1962.

Improved Methods and Equipment for Cutting Up and Packing Chickens.

Childs, R. E., Walters, R. E., White, H. D. 1963. Problems in Weighing and Packaging Chicken Parts to Exact Weights. A technical paper presented at the Annual Meeting of the American Society of Agricultural Engineers, Miami Beach, Florida, June 1963.

Walters, R. E., May, K. N., and Rodgers, P. D. 1963. The Relationship Between Chicken Parts and Carcass Weights. A technical paper presented at the Southern Agricultural Workers Conference, Memphis, Tenn. February 1963.

Walters, R. E., May, K. N. 1963. Thermal Conductivity and Density of Chicken Breast Muscle and Skin. Food Technology, June 1963.

Walters, R. E., May, K. N. and Rodgers, P. D. 1963. Relations of Weights and Sizes of Broiler Parts to Carcass Weights. Marketing Research Report No. 604, June 1963.

Shipping Containers

Hale, Philip W. and Chapogas, Peter G. 1963. New Shipping Containers for Short Hauls of Icepacked Poultry. Marketing Research Report 584, pp. 20.

Stokes, Donald R. 1963. Better Packaging - More Sales - Bigger Profits. Poultry and Eggs Weekly, June 1963.

COOPERATIVE MARKETING

Farmer Cooperative Service

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.0 man-years are on the cooperative marketing of citrus, 2.7 to cotton, 3.5 to dairy, 1.0 to deciduous fruit, 0.2 to forestry, 1.9 to grain, 2.6 to livestock, 1.3 to oilseeds and peanuts, 1.0 to potatoes, 2.7 to poultry, 0.2 to rice, 1.0 to sheep and wool, 0.1 to sugar, 1.0 to tobacco, and 1.0 to vegetables.

Research also is conducted under contract with land-grant colleges, universities, cooperatives and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Carolina, North Dakota and Oregon, and by two private research companies.

In addition, 15 case studies of individual or groups of cooperatives were completed. These were concerned with the improvement of operating methods and the feasibility of coordinating the marketing of two or more cooperatives.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Poultry

1. Improving fowl marketing. Work continued on a study to (1) examine and evaluate the present fowl marketing situation and (2) find and develop new and potential ways to increase producer returns from fowl. Additional findings on the first objective indicate that fowl pricing is closely related to broiler pricing, although competition and uses are usually unrelated. On the second objective, preliminary findings indicate that fowl prices at the farm may be improved by (1) further processing of fowl into new and convenient consumer products, (2) encouraging a more uniform flow of fowl to market, and (3) bargaining efforts of organized producers with buyers and processors.

2. Pooling and producer payment practices. Research was initiated to (1) determine pooling practices, bases of paying producers, and price differentials for quality, size, volume, regularity and uniformity of delivery of selected egg marketing cooperatives and other country egg handlers; (2) study the effect of size of producer shipments on costs; and (3) recommend improved pooling and more equitable producer payment practices which should lead to larger producer shipments, increased plant volume, and lower marketing costs per unit.

Early findings indicate that (1) pooling and producer payment practices vary widely among egg marketing cooperatives, (2) many cooperatives have adopted policies of producer price differentials, (3) price differentials have usually not been based on actual differences in handling costs, and (4) differences in pooling practices and price differentials are warranted by geographic and other conditions.

3. Improving operating methods. Work continued with cooperatives in various States to assist them in becoming more efficient in operation and more effective in marketing. Work was done with several associations in the Northeast to determine their operating costs in relation

to those of others and to suggest ways to lower unduly high costs. Considerable work has been done in three regions to assist cooperatives with problems of consolidation. Following these unification studies, mergers and consolidations have taken place in California and Utah.

A case study is underway to analyze one of the oldest and most progressive farmer cooperatives serving egg, broiler, and turkey producers. Findings to date indicate that the chief factors making for the growth and success have been (1) able and forward-looking leadership, (2) diversification of operations, (3) initiation and adoption of progressive and timely practices and operations, and (4) adherence to sound business and cooperative principles and practices.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

- Ratcliffe, H. E. 1963. In Unity There Is Strength. Article in Tri-County (Pa.) News.
- Scanlan, J. J. 1962. Laying It on the Line. Paper presented at American Farm Bureau Midwestern Egg Marketing Conference.
- Scanlan, J. J. 1962. The Role of Cooperative Effort in Marketing Eggs. Proceedings of the North Carolina Egg Marketing Conference.
- Scanlan, J. J. Jan. 1963. Poultry Co-ops--Often Community Lifeblood. Article in News for Farmer Cooperatives.
- Scanlan, J. J. 1963. Egg Marketing Cooperatives and Large Egg Producers. Paper presented at NEPPCO Poultry Industry Conference.
- Scanlan, J. J. 1963. Is It Too Late? American Cooperation, 1963.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: Within most agricultural processing industries rapid and drastic changes in their market organization and practices are occurring. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products. A significant aspect of the problem in marketing is that this type of information must be obtained from firms engaged in business -- in contrast with other types of research where the problem can be transferred to a laboratory, experimental plot, or other simulated situation. Consequently, it requires the cooperation of people engaged in making their living and assisting with marketing economic research on the side, where their own merchandise, facilities, and opportunity for profit and loss to themselves is involved. Another aspect of the problem is that only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

USDA PROGRAM

The Department has a continuing program to determine the reason for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. Because more than 50% of the consumer's dollar spent for meat products goes for marketing activities, this work encompasses a wide range of subject matter.

It covers all economic aspects of marketing from the time the products leave the farm until they are purchased by ultimate consumers. Much marketing research is functional in nature and could apply to a number of commodities.

A. Market Potentials for New Products and Uses

The Department has a continuing long-term program involving agricultural economists, economists and personnel with dual economic and technical training engaged in research to bridge the gap between laboratory developments and commercial adoption so as to assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and expanded markets that new products and new uses can afford. Research is

carried on in industrial and food uses at Washington, D. C., and five field offices -- agricultural economists are located at each of the four Utilization Research and Development Divisions, New Orleans, La.; Albany, Calif.; Philadelphia, Pa.; and Peoria, Ill.; and at the Hawaii Agricultural Experiment Station, Honolulu, Hawaii.

Of the Federal effort involving 20.5 professional man-years, 4.2 are devoted to animal products.

B. Merchandising and Promotion

The Department has a continuing long-term program of research in merchandising, management analysis, product distribution, and promotion evaluation, designed to provide useful information to producers, handlers, and distributors by which markets for farm products can be maintained and strengthened.

Merchandising research is conducted to quantitatively measure the impact of selected selling practices and pricing policies on sales of and demand for agricultural products. Research in this area is concerned with specific studies such as: Development of income-expenditure elasticities for selected products; identification of consumer and market profiles; and evaluation of alternative package sizes, displays, pricing techniques, and quality of products on consumer purchases. Along with the merchandising research is a relatively small undertaking involving management type studies designed to improve the efficiency of firms distributing farm products with work at the assembly and wholesale level being emphasized.

Research appraising and analyzing promotional programs of agricultural groups is directed toward studies such as: Organizational structure and procedures of commodity groups for optimum control, coordination, and effective conduct of program; measurement of levels of advertising and promotional intensity necessary to maximize sales; and evaluation of effectiveness of alternative appeals, themes, and techniques in selling farm products.

Of the Federal effort involving 17.6 professional man-years, 0.7 are devoted to poultry.

C. Economics of Product Quality

The Department's program of basic and applied research on the economics of product quality includes study of the problems of seven different commodity groups. Work on all commodities is carried on in Washington.

Of the Federal effort involving 14.3 professional man-years, 1.5 are devoted to poultry and eggs.

D. Marketing Costs, Margins and Efficiency

The Department has a continuing long-term program of research in marketing margins, costs, and efficiency designed primarily to provide useful information on the amounts and trends in marketing margins, costs of marketing, labor and equipment requirements, cost standards, economies of scale, and other factors including marketing practices, affecting costs of marketing through all important trade channels and types of firms and for all farm products marketed in commercial volumes. Most of the research is problem-solving in nature, and is conducted by professional agricultural economists. Some studies are conducted in close cooperation with agricultural engineers and members of other disciplines. In nearly all studies close cooperation is maintained with industry and trade groups and with private firms that generously provide essential data and make plant facilities available for observation and the conduct of various market tests. Although most of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located at field stations in several States. These agricultural economists work closely with State agricultural experiment stations which also share a part of the expense of the cooperative studies.

Of the Federal effort involving 42.2 professional man-years, including cooperative agents paid mainly from Federal funds, 6.8 are devoted to poultry and poultry products.

E. Market Structure, Practices and Competition

This is a continuing long-term program of economic research to assist farmers and marketing agencies to adapt to changes in market structure, practices and competition. Work in this area is conducted at Washington, D.C., at field offices in Berkeley, Calif., and Denver, Colo., at 20 experiment stations under cooperative agreements or contracts, and by a private firm under contract.

The Federal scientific effort devoted to economic research in this area totals 42.4 professional man-years, of which 4.8 is devoted to poultry.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Market Potentials for New Products and Uses

Research to determine distribution patterns and acceptance of dried and other egg products in remanufacturing uses was completed with the publication of a report during the year. Results indicate that dried egg products and egg containing prepared dry mixes will increase largely at the expense of frozen eggs. Convenience factors in the use of the dry products appeal strongly to users.

B. Merchandising and Promotion

Merchandising Broilers at Retail. In a controlled experiment conducted in cooperation with the National Broiler Council, total broiler sales were 16 percent greater when the quarter cut was added to the retail display than when no quarters were available. Retailers voluntarily assigned more display area to broilers when they added the extra cut, although added sales accompanied the presence of quarters even when adjustment was made for display. Sales were increased most in the market where retailers had featured quarters extensively prior to the study.

During the quarters test, three-fourths of the weekly fluctuations in broiler sales could be associated with price changes, newspaper advertising, display area, and volume of weekly business in the entire store. A broiler feature did not measurably affect meat department gross; while beef and pork specials by the test stores were highly related to increases in department sales. Meat dollar volume in test stores, however, was negatively related to increases in broiler features by other retailers.

C. Economics of Product Quality

Egg Quality, Costs and Returns. The effects of three factors -- full-time or part-time producer, size of flock, and size of egg -- on egg quality at 10 plants over a year's time are being analyzed. Later phases will deal with the causes of variation in quality and its effects on marketing costs and returns to producers.

D. Marketing Costs, Margins and Efficiency

1. Economies of Scale in Commercial Egg Packing Plants. Study of model egg packing plants under Southern conditions showed that costs decline from \$1.92 per case to \$1.45 per case as capacity is increased from 7 to 120 cases per hour. Preliminary analyses of egg contracting programs and other methods used to coordinate production and marketing operations indicate that highly integrated operations appear to have many advantages over non-integrated operations, particularly in meeting seasonal market requirements.

2. Commercial Hatchery Costs. Preliminary analyses of data from 30 egg-type chick and 27 turkey poultry hatcheries in 12 States show that operating costs per egg-type chick hatched are about 3 cents lower for hatcheries with large volumes than for those with small volumes. For turkeys, the difference was about 4 cents per poult. Seasonality of operations, use of obsolete equipment, combination of other services and sales functions with hatching, and low rates of performance are responsible for actual costs being above those for efficient model hatcheries.

3. Costs of Assembling and Processing Turkeys. Costs per pound in turkey processing plants decline under standardized conditions for all market classes as model plant capacity increases. However, most of the economies of scale can be realized by plants less than half as large as the largest model. For heavy young hens, these model plants can process 1500 and 4000 head per hour, respectively. Costs of assembling live turkeys are influenced by size of firm, density of the supply area, and performance efficiency in loading. Substantial savings can be realized in any size of assembly firm by standardizing operations and flock sizes and reducing the size of the supply area. Costs per unit of product increase with firm size (if density is constant), but not in proportion to volume.

4. Costs of Assembling Live Poultry. The live poultry assembly system in New England is changing rapidly. Newer types of firms, such as large processing plants, contract haulers, and contractors, have made tremendous gains at the expense of the older types and through extensive use of contract production. Margins for assembly have been reduced, but further substantial reductions are possible through increased efficiencies on the part of individual firms and further reductions in the number of firms engaged in assembling live poultry. About 330 New England firms assembled 470 million pounds of poultry in 1957 at a cost of \$4.6 million. These costs could be reduced to \$2.9 million through maximum efficiency in operations of each firm, eliminating overlapping procurement areas, and reducing the number of assembly firms by 60 percent so the remainder could operate at capacity.

5. Egg Margins. Farm-retail spreads for large eggs in ten cities averaged 24.2 cents a dozen in 1962--0.2 cent wider than in 1961. Retail store spreads were 0.5 cent wider, but farm-retailer spreads were 0.3 cent narrower. Egg prices were lower at all market levels. Farm-retail spreads for frying chickens in ten cities averaged 19.2 cents a pound in 1962--0.1 cent wider than in 1961. Retail store spreads widened 0.3 cent, but farm-retailer spreads narrowed 0.2 cent. Prices for frying chickens were higher at all market levels in 1962 than in 1961.

E. Market Structure, Practices and Competition

1. Pricing Eggs. Preliminary study indicates that the most commonly used base price quotations are those for New York City, Boston, Chicago and Los Angeles, with some overlapping between the areas in which they are used. In general, these quotations move together through time, although there are variations from day to day in the movements in various markets. Recommendations of members of the trade for improving the base price quotation system and for alternatives to it have been summarized and will form the basis for further research.

2. Egg Procurement by Large-Volume Distributors. Large-volume retailers are continually seeking sources of the lowest cost eggs consistent with the quality image they are trying to project. They must do so to remain competitive with other large-volume retailers. Thus, the producer-to-assembler-distributor-to-retailer marketing chain has become the most popular because it meets the competitive requirements of the retailers. It is much shorter than the older marketing chains and it may be indicative of the direction of future trends. Already even shorter marketing chains are being tried in various sections of the country. This is occurring where producers have volumes large enough to economically do the candling and cartoning functions on the farms and meet the requirements of individual retail stores of the large-volume retailers. Considerable analysis has been completed of the impact on procurement systems of production, distribution, and institutional considerations. Further analysis will be made of the impact on procurement systems of the retailer's and of the supplier's positions and objectives.

3. Integration in the Turkey Industry. Integration in the turkey industry is not as prevalent as in the broiler industry and has a wider range in types of integration. While contracting is the main form of integration, in some areas integration through ownership accounts for a substantial part of the production. This ownership may be by individuals or by closed stock corporations. Part of this study included an analysis of material on the extent of risk-sharing type contracts in 1961. Approximately 25 percent of the total U.S. production was under risk-sharing contracts, with the Western Region having almost 40 percent under risk-sharing contracts and the North Atlantic Region showing less than 5 percent under such contracts.

4. Changes in Marketing Eggs. Preliminary analysis of a New York egg marketing survey for June 1963 indicates that since the June 1959 survey: (1) Large-volume retailers have generally discontinued their candling and cartoning operations, and now receive eggs in cartons at their central warehouses or have them delivered direct to their retail stores; (2) the South has become a major source of supply for eggs in the New York market; and (3) in New York, Pennsylvania, and New Jersey, flexible formula differentials between farm prices and the New York spot quotations narrowed.

5. Special Sales of Fryers. Typical special sales prices for fryers featured in newspapers in ten cities averaged about 11 cents a pound lower than non-sales prices reported by BLS for the same cities in 1960-61. Advertising apparently had a significant effect on the increased volume of fryers sold by retailers--some sold more than three times as many fryers during special sales weeks as during nonsale weeks. Quantities of fryers sold could be increased with little or no change in price, if the commodity were advertised. A reduction of 1 percent in price without advertising resulted in an average increase of 1.75 percent in sales; with advertising, sales increased an average of 1.91 percent.

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION -
HOUSEHOLD AND INDUSTRIAL
Statistical Reporting Service

Problem: With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increases returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

In addition to surveys of consumer preferences and discrimination, the Special Surveys Branch also provides consultants and conducts special studies, upon request, for other agencies in the U. S. Department of Agriculture or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The work of the Branch is carried out in cooperation with other Federal governmental agencies; divisions within the U. S. Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land-grant colleges; and agricultural producer, processor, and distributor groups.

Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D. C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years under regular program funds. An additional 0.1 professional man-year was devoted to research conducted under a transfer of funds arrangement.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Poultry

A contract has been signed with a private research firm to conduct a survey designed to provide a current evaluation of the household market for poultry. Production of both broilers and turkeys has been very high, and prices have been very low. Many business failures have resulted. The overall objective of the proposed research is to obtain information from homemakers which will provide insights into the measures which might be taken by the poultry industry to market poultry more effectively and to increase demand among household consumers. Although the proposed project will be similar in some respects to a 1956 USDA study, the questions to be asked will be revised extensively to reflect the many changes which have occurred in the poultry industry in the past six or seven years and to obtain information on current problems.

ECONOMIC AND STATISTICAL ANALYSIS

Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

USDA PROGRAM

The program includes the regular publication of 11 commodity outlook reports; holding of the Annual Outlook Conference in Washington in mid-November; participation of commodity specialists at regional or State outlook meetings or at meetings of farm organizations and agricultural industry groups; preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities; issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities; long-range projections of supply of and demand for the major agricultural commodities; and continuing analysis of the impact of existing and proposed alternative farm programs as they affect output, utilization and prices of these commodities.

The total commodity situation and outlook program currently involves 22 professional man-years.

Poultry. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation for poultry and eggs. Appraisals are published 5 times a year in the Poultry and Egg Situation, quarterly in the Demand and Price Situation and the National Food Situation, and monthly in the Farm Index. A comprehensive analysis of the poultry and egg situation is presented at the Annual Outlook Conference. Appraisals also are frequently presented at regional or State outlook meetings, at meetings of farm organizations and to various agricultural industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply and consumption of poultry and poultry products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis. Wide fluctuations in returns from producing eggs, broilers, and turkeys, make imperative an effective outlook service for producers of these commodities.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Poultry and Eggs

In 1962, prices to producers for broilers and turkeys rebounded sharply from the extremely depressed levels of 1961. Egg prices, however, which were relatively favorable in 1961 were lower in 1962. Turkey production was reduced substantially but broiler production was up a little. Much of the recovery stemmed from some increase in demand. But part of the rise in price appeared to represent the re-establishment of the "normal" price-quantity relationships which were thrown out of kilter in 1961 by a chaotic merchandising situation. Late in 1962, higher feed prices than a year earlier began to arrest the output of broilers and also turkeys and eggs. The higher feed prices occurred in the months surrounding the main hatching season when producers can most easily adjust output. Consequently, the number of turkeys and flock replacement chickens being raised in 1963 is not differing appreciably from 1962. Prices to producers for turkeys and eggs this year will probably average about the same to a little higher than last year. But broiler prices will average lower. Also, a significant expansion occurred in the Nation's broiler hatchery supply flock in 1963 which will create pressure for large production and low prices in early 1964.

In the past year some exploratory work was done in identifying and measuring the impact of factors that influence the level of poultry production. The effect of the new Common Market trade regulations against U.S. poultry, and analysis of surplus removal programs also received considerable attention. An article in the November 1962 issue of the Poultry and Egg Situation focused attention on year-to-year changes in poultry production and how they have been related to changes in profitability of production. The analysis employed a ratio of an index of prices received for broilers and turkeys to an index of production costs--a more refined measure of profitability than the product-feed ratios often used. The July issue featured an article on the cycles in broilers, which contributed to a better understanding of the forces generating recurring periods of overproduction and depressed prices in the broiler industry. This analysis provided the basis for a special press release issued by the Department on July 1 urging the broiler industry to exercise caution in production planning. Long-run projections (5 years) were developed as part of a set of ERS projections for the economy as a whole.

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